CHEMICAL
& Metallurgical
ENGINEERING

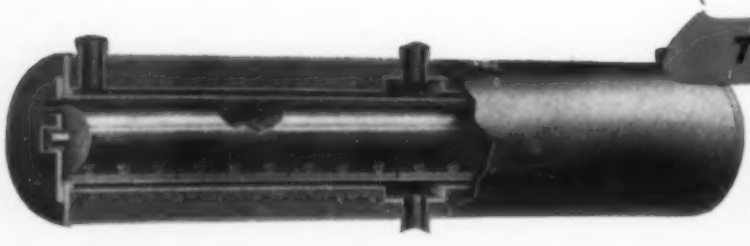
For MAY, 1944 • CHEM & MET REPORTS ON HEAT TRANSFER AND HEAT UTILIZATION • NEW TECHNOLOGY IN RECOVERING MAGNESIUM FROM MINERALS • LIGNUM-VITAE WOOD FOR CHEMICAL INDUSTRY USE • HOW TWENTY-SIX DETROIT ENGINEERING SOCIETIES COMBINE ACTIVITIES • RESIN TREATED WOOD FOR CONSTRUCTION

Dolomite Processing in International's Magnesium Plant at Austin, Tex.

VOTATOR is the "Double Header" Value in Processing Equipment!

1. HEATS OR COOLS IN SECONDS AND CONTINUOUSLY
2. MIXES, AERATES, PLASTICIZES . . . SIMULTANEOUSLY

You can do these *two* processing steps at one time with one machine — the Votator! Equally important, in processing liquids or viscous materials, Votator does each step *faster and more efficiently*. Votator accomplishes this by passing a thin film at high speed over a large cylindrical heat transfer surface. The rotor and blades that continuously clean this heat transfer surface simultaneously mix the material. Being completely closed, air and moisture are kept out and gases can be introduced in desired quantities. Units are practically automatic, self-contained and compact, thereby assuring savings in space and labor. Consult with The Girdler Corporation, Votator Division, Louisville, Ky.



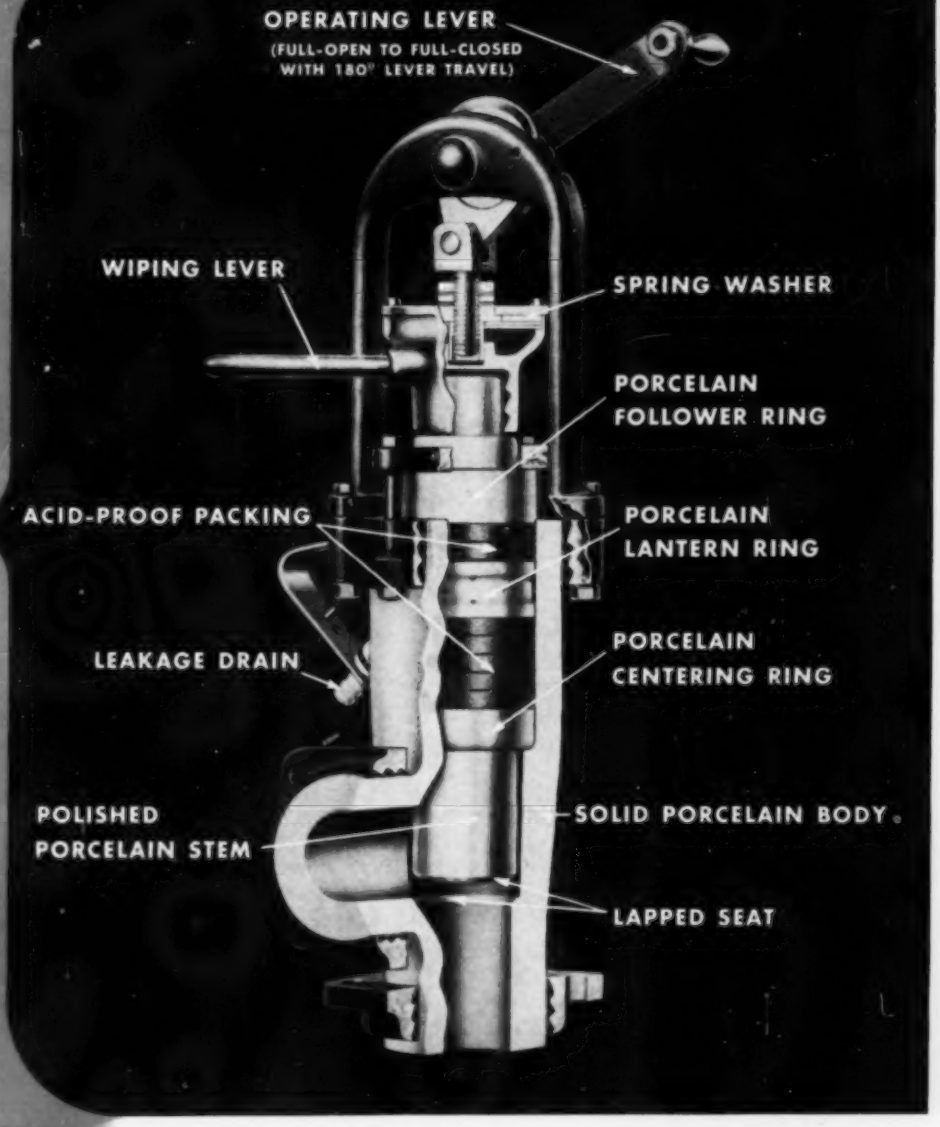
THE Votator*
A GIRDLER PRODUCT
*Trade Mark Registered U. S. Patent Office

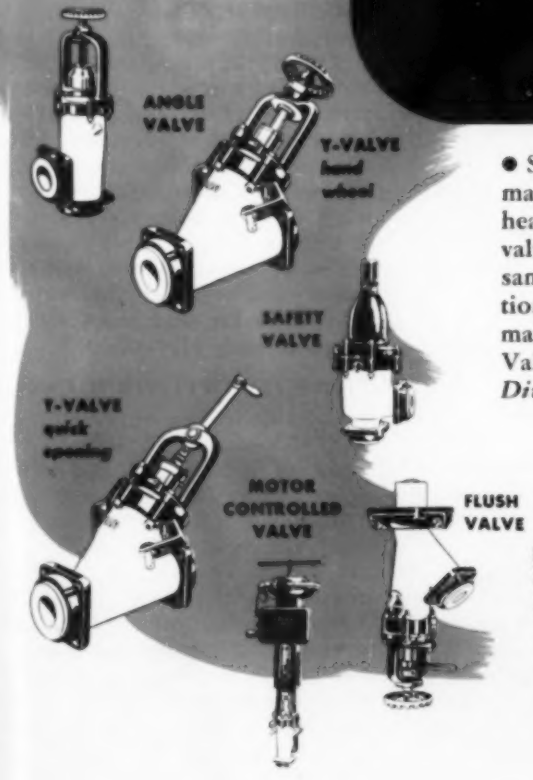
HERE'S HOW

PORCELAIN

IS ANSWERING MANY OF THE PROBLEMS YOU MAY FACE, IN THE HANDLING OF CORROSIVE CHEMICALS

★





● Study of the cut-away drawing of the Lapp Valve has determined many an engineer to try this equipment in his process. We've yet to hear of a case in which that judgment wasn't substantiated by the valves on the job. All the valves sketched at the left incorporate the same principles of construction. If you want to eliminate contamination, break-downs, shut-downs, slow-downs and maintenance, get some experience with Lapp Valves. *Lapp Insulator Co., Inc., Chemical Porcelain Division, LeRoy, N. Y.*

Lapp

Chemical Porcelain

WATCHING WASHINGTON

R. S. McBRIDE, Editorial Consultant • PAUL WOOTON, Chief of McGraw-Hill Washington Bureau • MALCOLM BURTON, Washington Correspondent

Government's agricultural lime policy gives the industry a case of jitters . . . Less red tape is now required to raise salaries . . . Insecticidal problems grow more complex . . . Wartime catalytic cracking units can be converted to peacetime uses . . . Politicians have won another round in annual corn-hog battle . . . Congress has decided contract termination is more important than surplus property disposal . . . WPB looks for operator for sulphuric acid plant . . . Shipping container situation looks bad . . . Orders for maintenance and repair items and for operating supplies should be placed further in advance . . . Vulnerable men who are indispensable number 6,000.

UNCLE SAM, LIME PEDDLER

During the past year agricultural lime has been supplied largely by distribution through Agricultural Adjustment Agency. Approximately 80 percent of the liming material put on the land was so delivered under the Soil Conservation program. Occasionally this easy method of selling causes a mild case of jitters in the lime industry, when it is realized that any change in government policy might leave the lime producers suddenly without any marketing or distributing facilities. It is still expected that AAA will distribute during the coming fiscal year another 14,000,000 tons, which is about the amount given away during 1943-44.

SALARY RAISES OKAYED

Not all individual salary increases require separate approval under war restrictions on pay rates. Salary stabilization regulations are now available to define the ways in which executives may pass on promotions which are based on a normal program previously used by the company. In many cases such increases are both proper and necessary to minimize the inducement to experienced workers which is otherwise offered by neighbor companies who can create a new job at a higher salary rate. The Bureau of Internal Revenue will supply new rules on request.

INSECTICIDE PROBLEMS

Insecticide problems grow more complex for public officials from month to month. Interlocked are demands for refrigerants and insecticides as well as the questions of garden protection, protection of the health of the army, and mere convenience factors of home and institutional nature.

The Chemicals Bureau of WPB now believes that it has in sight enough DDT for both military and essential civilian uses. The military applications extend far beyond direct army requirement. About 1,300,000 Neopolitans were provided with DDT for dusting, in order to check a dangerous typhus epidemic in Naples at the time of the American army's arrival there. Very extensive use of this chemical as a replacement for rotenone and derris continues through the aerosol method of distribution.

It is this use of freon for vaporizing and spraying of insecticides that is occasioning much of the tightening up on supply of that refrigerant gas both to industry and household. Essential refrigeration supplies are promised, but comfort applications are likely to be denied, according to estimates of WPB. A new help in this situation is the industrial supply of freon 22 which is monochlor-difluoro-methane. Freon-12 is the dichlor derivative. Both types will be scarce for some time.

CHILD LABOR RULES

Anticipating greatly increased employment of youths of 16 and 17 in industrial jobs, the Department of Labor is asking cooperation of employing companies. Seeking to prevent both discouragement and overwork of the young people, the joint conference with industrial leaders led to the following statement from the Department:

"These agencies directly connected with the production of war goods endorsed a combined work and school week of not more than 48 hours and a combined work and school day of not more than nine hours for 16- and 17-year-olds and urged upon manufacturers the observance of such standards as a means of making a more efficient use of their student workers without serious loss to the young people's schooling. The endorsement gave support also to other recommendations on the use of young workers when they are needed."

POSTWAR FOR HIGH-OCTANE

Reviewing the war program which has involved spending of $760,000,000 by the government for 100-octane aviation gasoline or its components, Petroleum Administrator Ickes has recently been emphasizing postwar usefulness of this flexible modern refining equipment. One of his most significant forecasts was:

"For one thing, expansion in both commercial and private flying is expected to provide a continuing market for considerable quantities of aviation fuel. For another, many of the new catalytic cracking units that have been built as part of the war program can be converted to peacetime use to increase both the quantity and quality of postwar motor gasoline. To a certain extent, the same can be said of facilities for producing various types of blending agents used in 100-octane fuel."

Further comment by Deputy Administrator Ralph K. Davies was particularly interesting:

"Probably no other major war industry has so small a proportion of Government participation. Eighty-two percent of the ultimate capacity of 100-octane plants in the United States will be privately owned. In terms of investment, private companies will have obligated roughly $550,000,000 of their own money in the expansion of 100-octane facilities between Pearl Harbor and the end of 1944. Government investment in the same period will come to approximately $210,000,000."

PUBLICITY TO CONTROL CARTELS

Cartel control is being sought by Senator O'Mahoney, conspicuous leader of anti-monopoly legislation, through a bill which he is pressing for enactment this year. That measure (S. 1476), as now advocated, is expected to use publicity as the major means of restricting the influence of cartels on American business.

Under the form probably to be pressed, if enacted, this bill would require the recording in the Department of Justice of all sorts of foreign contracts. It would make such recorded information available to the public, with the expectation that both official prosecution could occur and

MASTER

SPEEDRANGERS

On many applications, variable speed operation offers tremendous advantages. The Master Speedranger provides this infinitely variable speed in a compact all-metal unit of proven reliability.

SIMPLE COMPACT DESIGN Only with an all-metal drive is it possible to secure the compactness, simplicity, flexibility and economy that are so advantageous on modern production machines and processes.

ALL-METAL The all-metal construction insures long life and the greatest possible freedom from interruptions to service. The design is extremely simple, consisting of a metal ring which operates at a variable position on the two driving and two driven cones. The position of the ring on the cones determines the speed of the output shaft.

PROVEN RELIABILITY Millions of hours of service in the field and exhaustive tests in the laboratory have proven conclusively the complete reliability of this device.

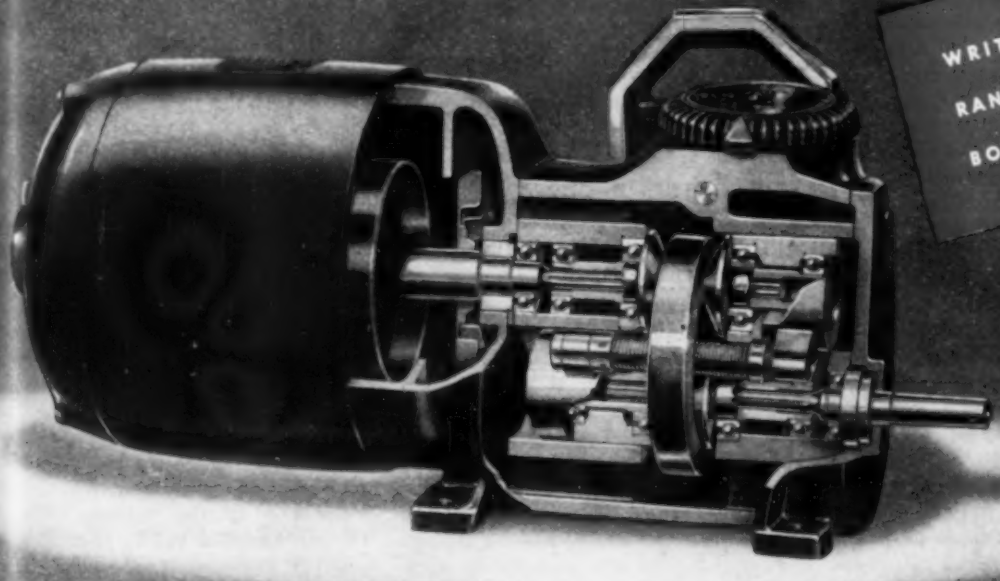
EXTREME FLEXIBILITY Speedrangers can be supplied for single phase, polyphase, or direct current operation. They can be furnished also with integrally built gear reduction units and electric brakes . . . in enclosed, splash proof, fan cooled or explosion proof construction and for a wide variety of mounting arrangements. No other variable speed unit on the market today can give you such flexibility and compactness.

UNDIVIDED RESPONSIBILITY The complete Speedranger is designed and built in one plant by one manufacturer as an integral, compact power unit.

HORSEPOWER Now available in sizes up to and including 3 horsepower.

SPEED RANGES Up to 9 to 1 are available. (Up to 15 to 1 in some sizes.)

THE MASTER ELECTRIC COMPANY • DAYTON 1, OHIO



WRITE FOR A SPEED-RANGER DESCRIPTIVE BOOKLET DATA 7525C

competitors could take advantage of the information so released. Under discussion with the Senator are means for restricting the publicity in such a manner as not unreasonably to release facts having only confidential trade significance. Also uncertain is the question as to how exception will be granted from the requirement of filing of what are merely business agreements for purchase or sale involving no monopolistic or trade restraint characteristics. As first drafted, the measure does not attempt to extend any of the anti-trust laws to include these international dealings. The apparent philosophy is to secure regulation by giving both the government officials and injured competitors knowledge of the facts on which either prosecution or retaliatory trade arrangements may be based.

SPECIAL COALS CONSERVED

To insure needed special coal for coking, gas making, and other highly specialized demands, it has been ordered that these coals be saved for such purchasers to the extent that they are needed. This action by the Solid Fuels Administrator protects many process industry fuel supplies of distinctive character, but such purchasers are expected to stock their coal or place advance orders promptly. Other industrial fuel users are also urged by WPB Chairman Nelson to place orders and accept more than seasonal requirements of fuel whenever mining and transportation facilities permit early delivery.

CORN-HOG BATTLE CONTINUES

Politicians have won another round in what seems to be the annual corn-hog battle. The set-aside order of March failed to provide the corn necessary to keep the wet millers in operation. War Food Administration's April action was a freeze order on the sale of corn by farmers and elevators of 125 mid-western counties. The government will be the only purchaser of corn in the designated counties until late in June, 60 days from the time the order was put into effect.

Last year's tactics are to be used. Local AAA representatives will make the rounds endeavoring to persuade the farmers to sell their corn to the government. The 1943 ceiling price of $1.16 per bushel at Chicago will prevail, but the farmer will receive an indirect subsidy. Commodity Credit Corporation, the government purchasing organization, will pay for the shelling and transportation to the elevator, costs that are ordinarily borne by the farmer. It is hoped that this procedure will secure 80,000,000 bushels of corn which the government will divert to the corn processors.

This ends temporarily a terrific behind-the-scenes battle between those favoring the political approach to the problem and those taking the more practical viewpoint. The latter claim, with some justification, that there would be plenty of corn for industrial use and for sale in deficit feed areas if the government would reduce the weight on which the support price for hogs is paid. Suggested is the more economical feeding weight of 210 lb. instead of the present 230 limit, which is a reduction of 10 lb. from the weight set when the support price was originally put into effect.

CONTRACT TERMINATION

Important leaders in Congress have decided that contract termination legislation is much more important than postwar surplus property disposal. Thus precedence is being given to the measures which deal with cancellation of war contracts and termination of agreements between government and industry. This will slow down, probably until after the Congressional recess of the summer, the enactment of legislation to support the Baruch surplus property report. This is true despite a disclaimer on the part of the Senate committee interested that the surplus disposal legislation need not necessarily be delayed.

TRAINING FOR RECONSTRUCTION

An idea to develop an export sales potential for U. S. industrial output by training future foreign industrial leaders in U. S. mechanical methods and standards has been developed by the Foreign Economic Administration. It will be presented to the Council of Ministers of Education of the United Nations by the State Department. The plan was originated by Alex Taub, FEA's chief engineer.

Selected foreign college graduates would be brought to this country for 18 months of concentrated schooling in chemical engineering, food processing, and other technical subjects. The plan envisions instructions at university laboratories and industrial plants where the subjects can be presented as complete pictures and demonstrated locally—chemical engineering at the University of Michigan, food at Wisconsin, power at Purdue, electricity at Union College in Schenectady. American college graduates would also be enrolled in the course to prepare them for foreign service to help in the reconstruction of devastated industries.

ACID PLANT NEGOTIATIONS

WPB announced that it was seeking a firm to operate the sulphuric acid plant of Gopher Ordnance Works in Minnesota. Slightly earlier an attempt was made to get commercial action at the explosives manufacturing plant in Wisconsin, which also was closed as a part of the readjustment of the military ammunition program.

Several firms indicated their interest in operating the Gopher acid facilities, even though this was conditioned on erection and operation of a superphosphate plant. Final plans contemplated manufacture of approximately 200,000 tons per year of superphosphate there, in order to increase the supplies of fertilizer in the north central area of the country. One of the major backers of this undertaking is Agricultural Adjustment Agency which wishes to have both immediately and later a surplus of superphosphate of which to make use in inducing farmers to support the AAA soil improvement program.

It is understood that the Wisconsin facilities will all be used for industrial purposes other than fertilizer. The report is that permission was given to the Chemicals Bureau of WPB for such an arrangement on condition that it insist on fertilizer making in Minnesota. Although no such details are stated even unofficially by government representatives, it is generally accepted in Washington that some such "trade" was necessary.

SEVERAL BIDS EXPECTED

Officials expected several chemical and fertilizer manufacturers to offer conditions under which they will handle the Gopher Ordnance Works and facilities. The successful offer must conform with the following requirements:

An application on form WPB-617 must cover the conversion of the oleum plant and construction of superphosphate facilities. A proposed financial program must be offered; and if Federal funds are used, a definite rental plan for government facilities must be set forth.

WPB must know the experience of the applicant in both acid and superphosphate business, and the quantity of each to be made. An important factor will be the policy of the company regarding adding fertilizer business in the Minnesota-Wisconsin area, both commercially and with AAA. The successful bidder will be the one that offers the most favorable terms, including shortest time to get into operation, minimum number of employees to do the job, and other factors important in wartime.

WANTED: LONG FIBER KRAFT

From any angle the shipping container situation looks bad. Lumber for boxing is probably the most critical container product as the end of the second quarter of the year approaches. Paper and paperboard, the substitute for many other packaging materials and the basis for the Army's "V" box made of laminated fiberboard, is in very short supply. A paint manufacturer with the highest military priority rating found on recent inquiry that the best delivery he could get in carload lots was from six to eight months. Contributing factor to the situation was the shortage of pulp which has prevented the box manufacturers from working at capacity.

Speaking to the industry, Rex W. Hovey, director of WPB's Paper Division, said that the production of the essential

RASCHIG RINGS

of PORCELAIN • STONEWARE • CARBON • STEEL

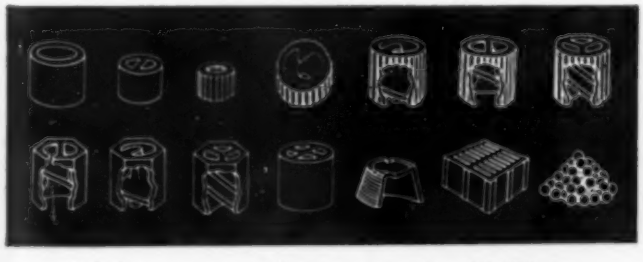
"U. S. Stoneware" raschig rings are available for prompt shipment in all standard sizes from ¼" O.D. up. "U. S. Stoneware" rings are made in four materials, each designed to fit specific processing requirements:

White Porcelain Rings: Characterized by zero-porosity, high chemical purity, great mechanical strength. Cannot contaminate any solution. Unaffected by any acids except hydrofluoric.

Chemical Stoneware Rings: Non-porous, non-absorbent, contain no soluble organic filler. Thin-walled, triple strength construction. Dense, granite-like structure will withstand high crushing stress. Inert to the action of all acids, solvents, gases (except hydrofluoric) in any concentration.

Carbon Rings: For use with hot caustics, mixtures of hydrofluoric and sulphuric, or hydrofluoric and phosphoric acids. Rings are all carbon, with no soluble bond. Light in weight (20% to 30% less than chemical stoneware).

Steel or Alloy Rings: For high temperature reactions, and for hot caustic soda solutions. Thin-walled, lightweight, butted construction. Can be made in any metal.



U. S. Stoneware manufactures more than 15 different styles and types of tower packing, each offering individual characteristics to meet highly specific needs.

THIS NEW FREE BOOKLET GIVES THE ANSWERS TO QUESTIONS LIKE THESE

What's the per cent of free gas space of a 1" raschig ring?
How many square feet of exposed absorption surface per cubic foot?
What's the relative scrubbing capacity?
How can we reduce the resistance to gas flow?

For the answers to these and to innumerable other questions about tower packing and tower construction, write for a free copy of our new authoritative booklet—"Tower Packing." Address your requests to Department P. The U. S. Stoneware Company, Akron 9, Ohio.

Now! **RASCHIG RINGS FROM CERATHERM**
the new heat-shock resistant stoneware

For tower operations involving high heat, or repeated and severe thermal shocks, raschig rings of Ceratherm, U. S. Stoneware's remarkable new ceramic body, are ideal. Ceratherm rings will not chip, crack, or spall even under rapid heating and cooling. 27% stronger mechanically than ordinary stoneware — 400% greater heat conductivity. Non-porous, non-absorbent.

U. S. STONEWARE

Since 1865 • Akron, Ohio

IN CANADA: CHAMBERLAIN ENGINEERING, LTD., MONTREAL

kraft paper must be built up to meet the demands of the country. "We need 50,000 more tons a month than we are getting," he said.

If the southern mills making unbleached long fiber paper can be kept operating at 110 percent of capacity, it is believed that the problem can be solved. But if the additional production is not forthcoming, there will not be enough long fiber kraft to meet the demand for waterproof paper, multi-walled bags and other overseas packaging. The real pinch will be felt in the third and fourth quarters of this year should pulp production lag. The fiber container quota was not met in the first quarter and in the second quarter indications are that production will be approximately 75 percent of requirements. Tin cannot be used to help out in this tight situation.

Even though the production of pulpwood in the first quarter of 1944 was 25 percent above the first quarter of 1943, the situation will not be improved. Most of the added production is in short fiber wood. The present deficiency is in long fiber. Drafting of 18 to 26 yr. old men is also expected to affect future supplies. Eight percent of the pulp cutters in the southern area and four percent in the eastern area are in the 18 to 26 yr. old bracket.

Although negotiations have been completed with Canada for the importation of more pulpwood and saw logs than in previous years, there is no real hope of importing a sufficient amount of pulp to improve the paper situation.

SHELLAC UNLIMITED

Over the opposition of the Shellac Industry Advisory Committee, order M-106, controlling distribution of shellac, was revoked in mid-April. The industry expressed the feeling that complete relaxation of all control would disrupt the market. Government officials explained that since the alcohol available to shellac producers has been reduced from 100 to 50 percent of their base period use there would be no chance of a runaway following the revocation of order M-106. Briefly, there is enough orange shellac but not enough alcohol. Also, there will be but slight increase in supplies of bleached shellac because of the limited amounts of raw materials available for bleaching purposes.

LIQUID FUEL SYNTHESIS

Authorization for a five-year research program on the synthesis of liquid fuels was given definitely in a bill signed by the President. This act of Congress authorizes later appropriation of $30,000,000 for demonstration plants to be built and operated by the U. S. Bureau of Mines.

Work of the first fiscal year under the direction of Dr. Arno C. Fieldner will probably include principally chemical engineering unit operation studies at the Pittsburgh station of the Bureau. Some of the larger unit equipment, especially for the Fischer-Tropsch process, is likely to be placed at the sub-station near Bruceton, a suburb of Pittsburgh, where the Bureau has other large-scale research in progress.

Field studies and preliminary designs for a demonstration plant, in the Rocky Mountain States using oil shale as raw material will also be undertaken during the year. Lignite studies in the Dakotas will initially be limited to experimental work on making of synthesis gases from that low-grade solid fuel. The Bureau staff point out that the Fischer-Tropsch studies are most efficiently carried out in two parts. The first part deals with fuel gasification and purification of synthesis gases, work which can well be done near the source of raw materials like lignite or natural gas. The synthesis studies can start with such gas made from any material, even bituminous coal, and can best be carried out where other experimental facilities are at hand.

MANPOWER AFFECTS MRO

Orders for maintenance and repair items and for operating supplies should be placed further in advance. Manpower shortages have adversely affected production within industries in which chemical manufacturers must depend for equipment and repairs. Supply of most metals is much tighter than it has been since the first of the year. Lumber is in an almost hopeless position along with paper and paper containers of every category. Machinery and equipment are moving more slowly.

With the chemical industry still expanding and with production goals up as much as 25 percent above last year, equipment manufacturers are hard pressed to supply replacement parts for the more rapidly wearing industrial machine. From Washington the supply position of MRO items appears to be growing worse.

THE INDISPENSABLES

According to best estimates, the chemical industry, exclusive of petroleum and rubber, has about 300,000 employees. Of these, 30,000 are technical men, 25 percent of whom, or 7,500, are less than 26 years old and therefore vulnerable to the draft. It is estimated that ⅔ of these technical men, or 5,000, are indispensable. Of the 270,000 operating employees, 6 percent, or 16,200, are estimated to be less than 26 years old and therefore vulnerable, and about 5 percent of these men, or roughly 800, are indispensable. Combining the technical and operating men, the total of vulnerable men who are indispensable is estimated to be 5,800, which may be rounded off at 6,000. This figure of 6,000 indispensable men assumes a rigorous elimination of men who are not absolutely needed.

EMPLOYMENT OF WOMEN

Little hope is held that the employment of women in chemical plants can replace men sent to the Army in the draft. A hasty survey of the situation indicates women are being used as technicians in laboratory work but that they do not work out satisfactorily in the plants. While no official announcement along these lines has been made, government men privately say that a solution of the chemical industry's manpower problem lies along other roads. Employment of females in industry already is at the peak according to reliable authorities.

VITAL MANPOWER

"Are we now to accept the doctrine that we can win this war without any new contributions from science and the process industries?" asks one high official. "In the Press," he continues, "we read that the Germans have developed mysterious new uses of science. Where will this country be if some of these blossom forth after we have stripped our process industries of their scientifically trained young men who would otherwise be part of a going organization ready to take up the challenge and go the enemy one better?

"Back of our modern weapons and essential civilian economy are process industries, most of which revolve around modern engineering and science. Not only must these industries be kept healthy enough to do their present jobs; they must be kept ready to do new jobs. The educated, younger scientists and engineers with the newer training in new fields, a young point of view and physical stamina must be kept ready to do the jobs that modern warfare will unquestionably bring to some of them. To keep process industries virile, their better, young, productive scientists and engineers must be kept in their present jobs. Furthermore, in some cases, these engineers and chemists are not going to be much good unless we keep with them as members of their working teams some of the skilled operators who have never seen the inside of a college; this is especially true of chemical operators.

"In this war the miracles that are the synthetic rubber program, radar, penicillin and high octane have shown what can be done in a matter of months when well-organized, trained groups of scientists and engineers are on the job ready to go to work as teams.

"One cannot turn research on and off as one would a faucet, but if the trained group is there and the crisis comes, these trained groups can do miracles in very little time. Our enemies and our major allies realize this. After all, in terms of manpower, the probable number of men involved would not man two divisions. Military men know the value of reserves. The process industries and their trained scientists and engineers are 'reserves'."

DOW ANNOUNCES

another important price reduction in

STYRON

(DOW POLYSTYRENE)

In a move of far-reaching significance to the entire plastic industry, Dow announces a reduction in the base price of Styron (Dow Polystyrene)—from 30 to 27 cents per pound. The new low price, at which you may now obtain this strategic plastic from its source, is made possible by improved and vastly increased production.

Current rubber needs for styrene—chemical antecedent of polystyrene—are, of course, of major importance today. But, Dow's ability to lower the price of polystyrene places this plastic in a price range favorable to greatly extended uses for which this outstanding thermoplastic material has proved peculiarly adaptable. It will undoubtedly affect the design and manufacture of literally thousands of products now and when Peace returns.

Complete Styron price lists are available on request.

THE DOW CHEMICAL COMPANY, MIDLAND, MICHIGAN

New York • Boston • Philadelphia • Washington • Cleveland • Detroit • Chicago • St. Louis • Houston • San Francisco • Los Angeles • Seattle

DOW PLASTICS INCLUDE

STYRON . . . for fabricators producing moldings, extrusions, rod, sheet.

ETHOCEL . . . for fabricators producing moldings, extrusions, coatings; available also as Ethocel Sheeting.

SARAN . . . for fabricators producing moldings, extrusions, pipe, tubing, sheet; available also as Saran Film.

Write for New Dow Booklet "A Practical Approach to Plastics."

STYRON

(DOW POLYSTYRENE)

DOW PLASTICS

INTERPRETATIONS

This installment covers orders rules and regulations issued by the War Production Board and the Office of Price Administration during April, 1944. Copies of each item interpreted here may be obtained from the appropriate federal agency.

PINE TAR ALLOCATED

Pine tar has been placed under allocation for the first time as a schedule of General Allocation Order M-300. This became necessary since producers were loaded with orders, all of which bore the AA-1 rating previously assigned to this product, thus requiring WPB to issue a considerable number of AAA ratings. Allocations will be made on a monthly basis with a small order exemption of 5 gallons per month. Producers of less than 500 gallons of pine tar per month are exempted from the provisions of this Order.

JAPANESE TISSUE AVAILABLE

Limitation order L-297 has been revoked by WPB permitting the release of frozen stocks of Japanese tissue to domestic consumers. This is possible because the present supply is adequate and also because a suitable substitute has been developed in the United States. WPB points out that the manufacture and delivery of Japanese tissue remains subject to all other applicable regulation Orders.

PRICE RAISED ON SOY MEAL FOR ADHESIVES

Requirements of adhesives for use in the manufacture of plywood and paper containers have resulted in a shortage of one raw material, high-protein soybean meal. For this reason OPA by amending MPR No. 443, has increased the price of this material from $42 to $45 per ton f.o.b. Decatur, Ill. This product, produced by either the solvent process or the low temperature hydraulic process, is not suitable for livestock feed and the processing methods used are more costly. A premium grade of low moisture content soybean, the oil yield of which is lower, and the shrinkage of which is comparatively larger than other grades of the bean, is required to make this product.

HIGHER PRICE FOR BEET SUGAR FINAL MOLASSES

Revision of MPR No. 291 and amending of revised supplementary regulation 14 to the GMPR provides for increases in maximum prices for beet sugar final molasses, now limited in use to the manufacture of yeast and citric acid and its derivatives. This will alleviate in some measure the hardships suffered by sugar processors who are not allowed to rework for further extraction of sugar more than 40 percent of the amount used in the base period ending June 30, 1941. Formerly, processors had converted a large portion of the molasses into sugar, on which they realized a higher net return per ton.

LINSEED FOR PAINTS

Allocation of linseed oil for use in protective coatings has been increased from 50 percent to 60 percent of the quota under Allocation Order M-332. All of the increases are effected by changes in the number of pounds of linseed oil that may be used per gallon in pastes and ready-mixed paints as included in the table of products set forth in paragraph (b) (1) of the Order. One result of this increase in quota is the possibility of making gloss paint without titanium pigment of which there is a shortage. In addition, the increases will permit the production of gloss mill-whites which are used for general industrial painting where a high light reflection is necessary.

TANTALUM EXEMPTION INCREASED

Tantalum, used chiefly in the manufacture of electronic devices and chemical equipment, may be delivered or received in quantities up to 3 kilograms (about 6 pounds) per month without specific authorization by WPB. Applications for delivery must be filed by the seventh day of the second month preceding the month in which delivery is requested. Form WPB-1097 and 1102 should be used for these reports (Preference Order M-156).

MATERIAL SUBSTITUTION LIST

Issue No. 12 of the Material Substitution and Supply List released by the Conservation Division of the WPB divides materials into three groups of availability and shows several changes from the last issue. A number of fibers are in more plentiful supply as shown by the shifting of some grades of coir, istle, and hemp from Group II to Group III. Hard fibers remain critically short. Chemicals continued about the same with some plastics in better supply. Vegetable oils have eased, while some fish oils remain scarce.

NAPHTHA SHORTAGE

PAW has taken action to curb the use of naphtha as a motor fuel in order to insure adequate supplies for legitimate uses. By amending Petroleum Distribution Order No 18, PAW specifies that consumers and dealers cannot include in their quotas any petroleum product sold as a motor fuel during 1942. The Order makes it clear that naphtha may not be used as a motor fuel.

SCHEDULING REVISED

A new list designated as Table 6, as amended, has been issued under General Scheduling Order M-293. All products that were previously designated as "Y" or "Z" items have been reclassified as either undesignated, or "X" products. "X" items require manufacturers to file periodic shipping reports unless specifically exempted by WPB, whereas undesignated items are exempt from such reports unless specifically ordered by WPB.

The new list also excludes water distilling plants from the classification of heat exchangers. In addition, the exemption for orders on repair and spare parts under $1,000 for high pressure blowers and the exemption for certain types of blowers below 20 horsepower were eliminated.

OTHER ORDERS

Limitation Order L-83 has been amended by WPB increasing from $1,000 to $2,000 the permitted purchase in any four-week period of repair and maintenance parts for paper mill machinery. More than $2000 may be spent only in the event of an actual breakdown or suspension of operations.

WPB has allocated 214 drums of carbon tetrachloride per month for distribution among dry cleaners who are not equipped to use petroleum solvents. This allocation represents less than 5 percent of the normal consumption for dry cleaning purposes.

Amendment of Limitation Order L-193 removes the restrictions on the use of alloy steel for conveyor chains and sprockets. Also, restrictions on the use of iron and steel in bunkers, conveyor structures and other items were removed.

Because of easier supply conditions, WPB amended Allocation Order M-307 to provide an increase from 1,000 to 2,000 pounds per month in the small order exemption for casein used in paper coatings, glues, synthetic rubber, paint and for other purposes.

All restrictions on the use of coarse grit aluminum oxide abrasive grain in bonded and coated abrasive products, as well as limitations on the types of rubber-bonded abrasive product which may be manufactured, were eliminated by WPB through revocation of Conservation Order M-319-a.

Order M-261, which prohibited the use of steel strapping for domestic shipments not exceeding 90 pounds, has been revoked. A very small amount of steel will be required for the additional strapping, whereas the shortage of paper adhesive tape, rope and twine will be greatly alleviated.

Sales of used pressure vessels and enclosed atmospheric pressure vessels which are installed under ground, and purchased for use in their present location, are exempt from price control according to amendments to MPR-465 and MPR-136 issued by OPA.

CHEMICAL
& Metallurgical
ENGINEERING

ESTABLISHED 1902 S. D. KIRKPATRICK, Editor

MAY, 1944

Transfer of Heat—and Ideas

ONE of the most useful things we have learned from this war is that technical progress is accelerated by the free exchange of information on the results of research. The synthetic-rubber and aviation-gasoline programs show what can be accomplished through cooperation of technologists drawn from normally competitive enterprises. Some argue that this whole scheme should be transplanted in full scale into the postwar era—with a continuation of perhaps only a minimum of governmental supervision and direction. Were we not convinced that in actual practice that minimum might eventually grow into a monster of political domination and dictatorship, we could see a number of advantages in such a plan.

It has been most unfortunate in the past that we have set up arbitrary barriers that have often prevented the interchange of information among those who can make most use of it. The important field of heat transfer, which is explored in this issue by our colleague, Mr. Olive, and his co-authors, is a case in point. Too often those who know most about this subject have been literally "talking to themselves." They have fostered little discussion groups of their own kind to talk a language with which the average engineer will not bother, that has been all too slowly translated into general engineering practice. There has been a gap between the scientist and the engineer that many practical men have found difficult to bridge. What *Chem. & Met.* contributes with its current report is only the barest start. The problem needs much more constructive work and broad, cooperative thinking.

A sound approach to the whole subject of technical cooperation on chemical engineering research has recently been suggested by the eminent engineering consultant and author, Walter L. Badger. He would set up a clearing house for research problems relating to all the unit operations. This agency, which he hoped might be of private origin rather than a bureau of government sponsorship, could exert a tremendous influence in getting research started and directed along the most productive lines. Working with the universities, as well as with industrial organizations, it could assign and perhaps obtain financial support for many fundamental studies that are badly needed but could not be expected to yield immediately profitable results. The prompt publication and free interchange of information on these problems and projects through such a clearing house would help to advance the whole field of chemical engineering, at the same time revealing needs, and therefore opportunities, for further studies.

Badger is almost another Kettering when it comes to admitting how little we know about some of the things we take for granted. For instance, we know that heat transfer between contacting solid surfaces will increase with the smoothness of those surfaces. But how smooth is smooth? Apparently no one has attempted any quantitative correlations of surface conditions and heat transfer. Nor, according to Mr. Badger, do we really know what actually happens during the condensation of steam inside of pipes. We make some assumptions and derive some rates of condensation that have almost invariably resulted in over-design and capacity of steam condensers.

Similar problems—and promises—can undoubtedly be drawn from other fields than that of heat transfer. But this unit operation is one of timely interest to us this month in *Chem. & Met.* and also of basic importance since it affects the manufacturing processes of practically all our industries. If, therefore, through further cooperation or the setting up of such a clearing house as Mr. Badger proposes, we can promote ways and means of transferring ideas among research groups and in turn assist in translating that research into better engineering practice, we will have salvaged something eminently worthwhile from our war experiences.

Better Utilization of Mineral Resources

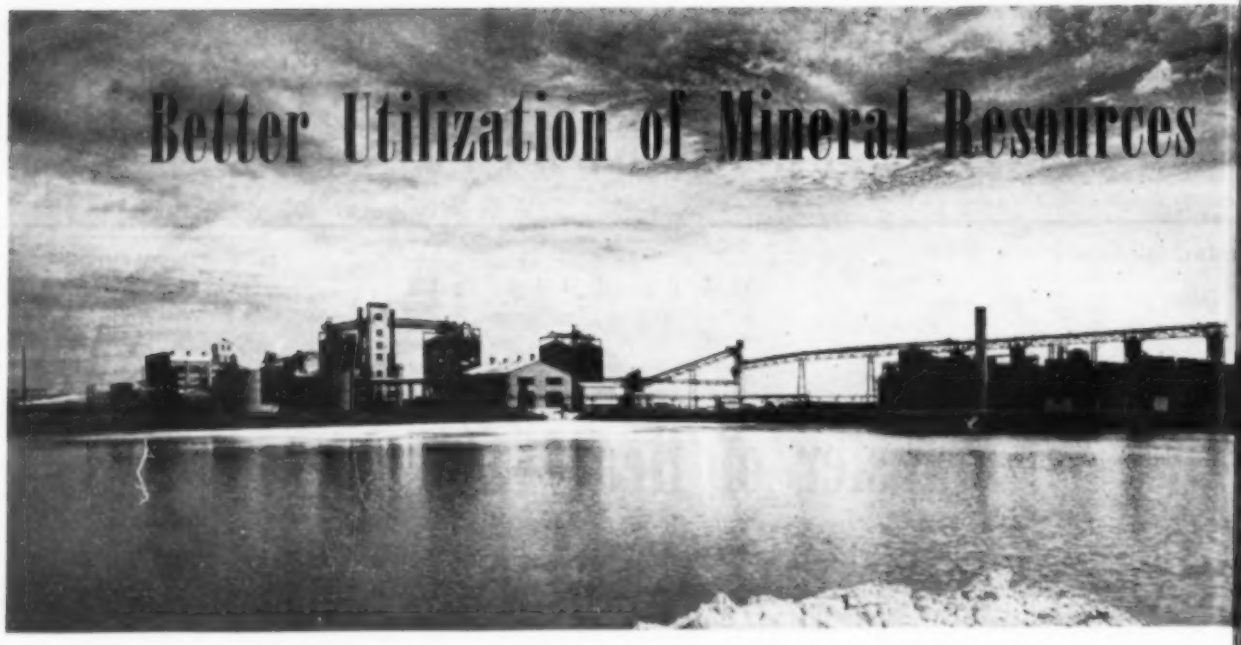


Fig. 1 — International's new magnesium plant silhouettes against the skyline at Austin, Tex.

War demands for magnesium and its chemical raw materials have served to emphasize the importance of our mineral resources and the need for their conservation through efficient utilization. The chemical engineer has been quick to accept this challenge. He has applied the methods of physico-chemical research to intricate problems of inorganic chemical reactions, and followed through with the development of effective manufacturing processes utilizing the best of modern techniques in the application of the unit operations of chemical engineering. Thus—at long last, inorganic chemical technology is coming into its own—perhaps to parallel the striking advances that have characterized the dramatic rise of the industries based on organic chemistry.—*Editors*

THIS WAR, in contrast with its predecessor, has turned the spotlight on the inorganic chemical industries. These less glamorous sisters in the chemical family have finally come into their true inheritance. Without their contribution to the war effort, we would have been sorely handicapped for many metals, catalysts and essential chemicals.

The almost explosive expansion of the light metal industries put heavy demands on our mineral resources for aluminum and magnesium raw materials. New ore supplies had to be developed and older ones used more efficiently. Catalysts to aid in the production of aviation fuels and synthetic rubber called for many tons of new inorganic compounds. Cut off from foreign supplies of potash for fertilizer and chemical uses, we were in the fortunate position of being able to exploit our rich resources to yield new products of tremendous importance to industry and agriculture. In all of this progress, chemical engineering has played an important part.

Inorganic chemical engineering has had some of its most spectacular applications in the miraculous development of the American magnesium industry. Even before the United States entered the war it had become evident that our production would have to be multiplied many fold. We were dependent upon a single producer, whose process in turn was dependent upon magnesium chloride recovered from natural brines. Other sources of raw material were obviously needed and it is to the lasting credit of the Dow Chemical Co. that its researches succeeded in developing the process for magnesium recovery from the most abundant but most dilute of all sources—the sea. (See *Chem. & Met.*, Nov. 1941, pp. 73-84 and 130-3.) Next most abundant of the known sources of magnesium is probably dolomite and work done in Canada and the United States has helped to make this raw material available for use in a number of commercial processes. (See *Chem. & Met.*, April 1942, pp. 87 ff.)

One of the most concentrated sources of magnesium chloride and one that has been the subject of a great deal of interesting research is the solution obtained as a byproduct in the production of potassium sulphate in New Mexico. To present the process developed for its recovery in chemical and chemical engineering de is the purpose of this article.

POTASSIUM PRODUCTS AND BYPRODUCTS

In the great southwestern part of t United States lies the Permian Basin, which were deposited in past geolog ages, many different salines, includ salts of potassium, sodium and magnesi With the discovery of potash, the a around Carlsbad, New Mexico, was veloped until at the beginning of 1 three deposits were being commerci exploited by as many different compan

Although the New Mexico deposits known to contain a number of wat minerals, including sylvite, carnallite langbeinite, only sylvite and langbei have thus far been found in grade quantity to justify their commercial velopment. All three operators in Carlsbad area produce potassium chlor from the sylvite ore and the proces used, although each differs from t others, consist essentially in the separa of potassium chloride from its mixtu with sodium chloride and other impur in the ore.

In 1940, the Union Potash Co., wh was subsequently merged with the In national Minerals & Chemical Co opened up a deposit of langbeinite ore a began the production of washed langbe ite, freed from salt by quick washing w water. (See *Chem. & Met.*, Jan. 1941, 79.) Langbeinite is the double sulphate potassium and magnesium, $K_2SO_4 \cdot 2MgSO_4$. (See Table I.) and is found the 800-ft. level in the International m

To fill the demand for potassium s

PAUL D. V. MANNING and S. D. KIRKPATRICK*

Through

NEW CHEMICAL-TECHNOLOGY

hate, then unsatisfied because shipments f this product from Germany had been t off, a process was developed and in- alled for effecting an exchange of po- ssium and magnesium ions between sylv- e and langbeinite, thereby precipitating otassium sulphate from the complex solu- on. Phase relationships are such, how- ver, that it is not possible to recover all f the potassium as the sulphate and, due this and the presence of sodium chlo- de, the solution left after the removal f the crystallized sulphate contains po- ssium, sodium, magnesium, chlorine and lphate ions in a total concentration aver- ging about 30 percent of the contained olids. Of these constituents, the potassium nd magnesium chlorides and sulphates e of value but to realize this value, they ust be separated from each other and om sodium chloride and sodium sulphate. process for such a separation had been early completed at the beginning of 1941 hen the government began its search for agnesium chloride to be used as a raw aterial in alleviation of the shortage of agnesium metal.

RECOVERY OF MAGNESIUM CHLORIDE

At that time, sure production of the etal was attainable only by the electrolysis f molten magnesium chloride and the ffice of Production Management (WPB's redecessor) determined to build up quick roduction by that process. Sources of agnesium chloride were then sought. vailable were only the brines from the lichigan wells and sea water. Experi- ental work on the reaction of dolomite ith calcium chloride and carbon dioxide as under way and some deep wells in tah and Texas also showed promise of elding magnesium chloride. However, e to the very serious difficulties encoun- red in the operation of electrolytic cells here the melted cell feed contained cer- in impurities, some of these naturally vailable brines could not be used because was not economically possible to remove e unwanted constituents.

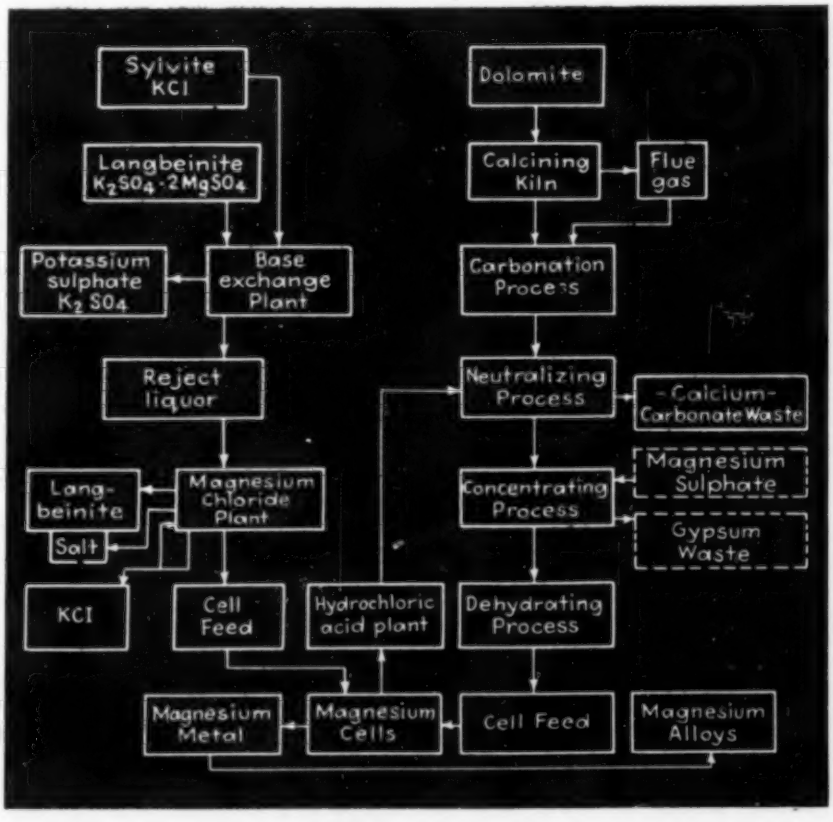
By study of phase relationships in the six component systems—Na – K – Mg – Cl – SO_4 – H_2O, it appeared possible to produce a cell feed of magnesium chloride pure enough to be used as a source of magnesium in the fused electroytic process. The ores from the Carlsbad mines contain only minute traces of substances other than those mentioned above and the process by which the ores are beneficiated and the potassium compounds produced is such that there is no tendency for these impurities to build up in the system.

Such rigid specifications, however, were very difficult to meet mainly because of the low sulphate content which was permitted in a product made from a raw material containing over 19 percent of SO_4 calculated on a moisture-free basis.

It must be realized that in the electrolysis of fused magnesium chloride by any process, the molten bath used in the magnesium cell is mainly a mixture of several chlorides such as NaCl, $CaCl_2$, $MgCl_2$ and KCl. Although some variation in percentage of each of the components is allowable, it is only possible between certain definite limits because such variation controls the important physical properties of the bath which, in turn, govern current efficiency and smoothness of operation of the cells. These properties include melting point of the bath, specific gravity, fluidity, surface tension, and electrical and heat conductivity.

Melting point is important because the

Fig. 2 — Process of manufacturing magnesium from New Mexico minerals and Texas dolomite



*Respectively, Vice-President in charge of Research, International Minerals & Chemical Corp., and Editor, *Chemical & Metallurgical Engineering*

Fig. 3 — Raymond mill, dehydrating sections and storage tanks during construction at Austin

bath must have the proper fluidity at a temperature high enough to maintain the metal in the molten state but not much higher lest the liberated metal burn too easily. Specific gravity must be such that the particles of molten magnesium can rise to the upper part of the bath and agglomerate.

In order to maintain the composition of the cell bath within the required composition limits, the magnesium chloride cell feed added must be of such a degree of purity that the composition of the cell bath can be maintained at the required point with the minimum removal of cell bath by dipping or "sludging." When it is necessary to remove cell bath, costs are increased because of the loss of chemicals and because of the labor required; also the rate of production tends to fall and the disposal of this waste cell bath constitutes a serious problem. In addition, there are likely to be minute particles of magnesium suspended in the bath and some direct waste of metal may thus result from the dipping of the bath.

REMOVING CELL FEED IMPURITIES

Maintaining smooth operation of the cells is important because this means lower labor costs and lower hazards to operators. This can only be attained by holding the cell bath to a proper composition and keeping the feed free from dangerous impurities. The danger point of certain of these unwanted substances is as low as 50 ppm. of cell feed. Unless the metal is to be purified after production, all sources of impurities must be constantly watched.

Considering the unwanted constituents in the brine available from International potash operations, the sulphate must be held as low as possible because it is decomposed in the cell with the ultimate formation of oxides of sulphur, a corresponding amount of carbon from the electrode being used in the reaction, thus increasing the electrode consumption per unit of magnesium produced. The sodium and potassium chloride must be held low enough to permit their removal with the usual amount of sludge withdrawn from the cells in order thus to maintain a constant composition of bath. For every ton of magnesium metal produced, almost four tons of anhydrous magnesium chloride must be fed to the cells and since it is not feasible to produce magnesium chloride as a pure anhydrous solid, the actual cell feed to be added approximates five tons per ton of metal produced. Hence if the cell feed contains, say, only 1 percent of a certain impurity, it will take into the cells, 100 lb. of this impurity with the amount of feed required to produce one ton of metal.

These reasons made necessary the very rigid and close specifications set up for the finished product to be made from the Carlsbad brine.

In the development of any process for the manufacture of a chemical, considerations of equipment and materials of construction do not ordinarily impose such great limitations as are encountered in the production of magnesium chloride. The salt itself is very soluble and unfortunately so, too, are most of the compounds with which it is associated. In addition to this, solutions of magnesium chloride have a very high boiling point rise, which of course increases with the concentration. The characteristic, however, which is responsible for the greatest amount of difficulty, is the hydrolysis of the chloride by heat according to the reaction: $MgCl_2 + H_2O = MgO + 2HCl$.

As the concentration of magnesium chloride increases, this hydrolysis progresses to an ever larger degree. Production of hydrochloric acid in this manner always results from concentration of magnesium-chloride solutions and the corrosion of equipment is, therefore, the greatest limiting factor in developing any process for the production of magnesium chloride.

For these reasons the use of multiple-effect evaporators in carrying out any concentrating operation which involves solutions of magnesium chloride is extremely difficult. Final dehydration of concentrated solutions also presents problems of considerable magnitude. In both cases as the concentration of magnesium chloride increases, the temperature to which it can be heated with minimum decomposition decreases. At the same time the vapor pressure also decreases and the boiling-point rise increases. In practice some hydrochloric acid is always formed and corrosion problems are inevitable.

In the accompanying diagrams (Figs. 4 and 5) there are shown phase diagrams of the process as finally developed.*

Brine is received from the potassium sulphate plant at the composition represented by A in the leonite field. It is fed to the third effect of the triple effect evaporator. This evaporator is a Swenson of outside-heater type, the bodies of the flash tank being of steel with Pyroflex and acid-proof brick lining. Heater tubes and tube sheets are of Inconel and vapor piping, entrainment traps and some of the heater shells are of Inconel-clad steel. This combination has shown excellent resistance against corrosion.

SO_4 REMOVAL AS LANGBEINITE

In the third effect, the liquor is concentrated to a composition represented by point *B* of the diagram and at this point liquors from point *E* are added and the liquor goes to the second effect of the evaporator. It is also reacted with salt being recycled from point *D* and this reaction and concentration results in a liquor of the composition indicated by the point *C* in the langbeinite field on the diagram. Salts crystallizing out at this point are langbeinite ($2MgSO_4.K_2SO_4$), sylvite (KCl) and halite (NaCl). (See Table I.)

Table I. Composition of Principal Salts Encountered in Recovery of Magnesium Chloride from Langbeinite

Salts	Formulas
Carnallite	$KCl.MgCl_2.6H_2O$
Sylvite	KCl
Halite	NaCl
Langbeinite	$K_2SO_4.2MgSO_4$
Leonite	$K_2SO_4.MgSO_4.4H_2O$
Schoenite	$K_2SO_4.MgSO_4.6H_2O$
Kieserite	$MgSO_4.H_2O$
Kainite	$KCl.MgSO_4.3H_2O$

These salts must be removed while the solution is hot and this is accomplished by Bird centrifugal filters. Langbeinite being the chief constituent of these rejected salts, this is the point where the removal of the sulphate from the system is effected. It is also the point of removal for sodium chloride. These salts are

*A *Chem. & Met.* pictured flowsheet of the magnesium chloride recovery process appears on pages 142-5 of this issue.—Ed.

turned to the potash refinery for utilization.

After separation in the Bird centrifugals, the clear liquor is fed to the first effect of the evaporator where the concentration is raised to that represented by point *D*. It will be noted that at this point the boiling point of the liquor is approximately 250 deg. F. The salts produced at this point are mainly kieserite, carnallite and halite and the slurry of these salts, thickened in a small settler are recycled back to point *C*. To the hot overflow from the settler, water and potassium chloride are added and after solution take place, the liquor is cooled in a batch vacuum crystallizer, the operation being represented at point *E* on the diagram. This crystallizes out pure carnallite from the solution. The carnallite is filtered and washed on the filter and is then leached with water to produce a liquor represented by point *A* in Fig. 5. The carnallite is decomposed to form a concentrated solution of magnesium chloride containing small amounts of potassium and magnesium chlorides. The remaining potassium chloride is present in the solid phase.

The slurry is filtered and the filtrate is concentrated in an Ozark submerged combustion gas burner evaporator until its composition reaches point *B* on the diagram. It is then chilled in the vacuum crystallizer to point C. This brings about the formation of carnallite and is done to reduce the potassium chloride content of the solution. Filtration removes the carnallite which is returned to the process and the liquor is passed to Peebles spray driers where it is dried. The drying process is so rapid that only a small amount of decomposition takes place and the final product contains but a small percentage of magnesium oxide.

The ratio of magnesium chloride to water in the product is approximately represented by $MgCl_2.H_2O$. After collection, the powder is briquetted and shipped to Austin, Texas, where it is electrolyzed in the modern Dow process plant which was designed and is operated for the Defense Plant Corp. by International Minerals & Chemical Corp.

One of the problems met at Carlsbad was that of water. The supply available from wells runs upwards of 8,000 ppm. of dissolved solids, containing all of the constituents of the potash brine and calcium salts as well. Because of the latter, this water cannot be used in the process for washing filter cakes, or for boiler feed. Consequently, all condensate from the triple-effect evaporator is saved and stored in a large sump. This water is circulated through cooling coils in the base of a large cooling tower. The evaporator condenser is a Schutte & Koerting eductor jet drawing its water supply from the supply passing from the sump through the cooling coils. The vacuum crystallizers also draw water from the same source. The

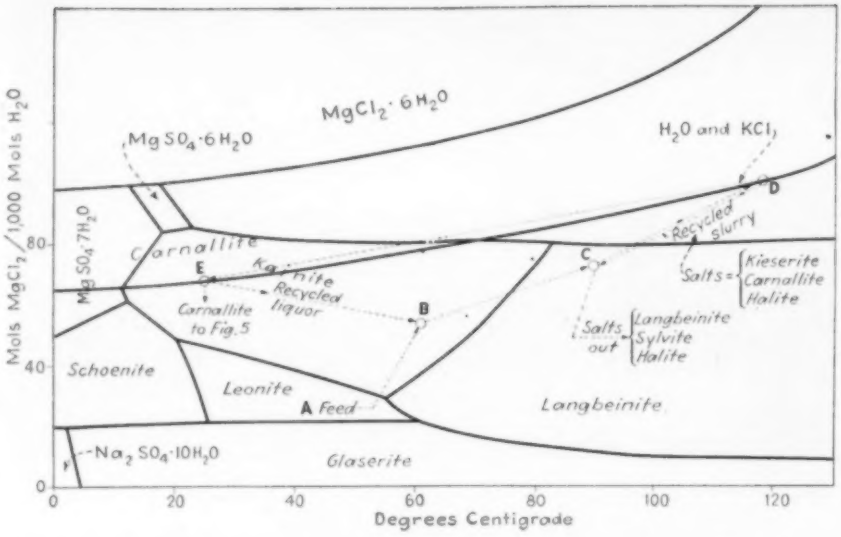


Fig. 4 — Phase flow diagram for III—II—1 evaporator flow. The plant feed liquor (line *A*) is fed to the third effect of a triple effect evaporator together with liquor recycled from point *E* where it is concentrated to a point represented by *B*. The reaction with the salts recycled from point *D* and the evaporation which takes place in the second effect of the evaporator raises the concentration of the liquor to point *C*. All the salts produced by both evaporation and reaction at *C* are removed. The liquor from *C* is then fed to the first effect where the concentration is raised to point *D*. The salts produced at *D* are recycled to *C* as a thickened slurry and to the liquor at *D* water and potassium chloride are added in preparation for the subsequent crystallization of carnallite. The crystallization of carnallite is accomplished in batch vacuum crystallizers and is represented by the line from *D* to *E*. At *E* the carnallite and its mother liquor are separated, the liquor recycled to point *B* and the carnallite advanced to the next section of the plant which is represented by the phase flow diagram shown in Fig. 5

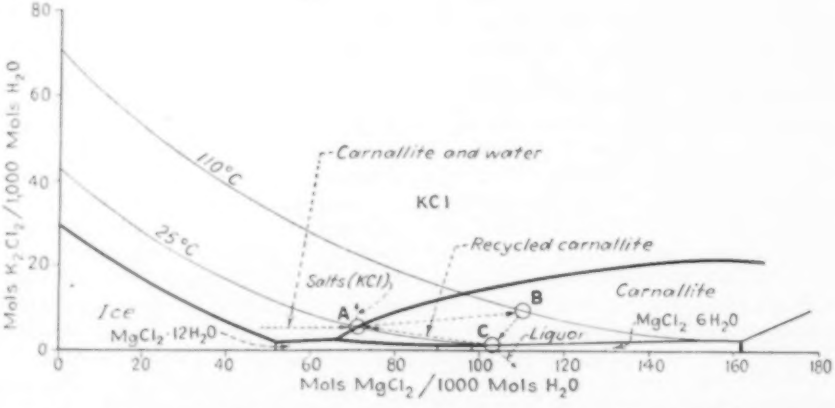


Fig. 5 — Phase flow diagram for carnallite treatment. The carnallite produced in the evaporator section of the plant is leached with water to produce a liquor represented by point *A*. After removing the salts (KCl) from the leach slurry, the liquor from point *A* is concentrated in a submerged combustion unit to point *B*. The liquor is then cooled to point *C*, thus crystallizing carnallite which is removed at *C* and recycled to *A*. The liquor from *C* is then dried for the final product

plant and boilers are in effect running on distilled water. Well water is used in the cooling tower on the outside of the cooling coils.

Because of war demands, it was necessary to hold the use of alloy steels to a minimum. All tanks handling hot solutions containing magnesium chloride are of brick-lined steel. The evaporator bodies, some of the crystallizers and salt settlers are of steel, lined first with Pyroflex and then with acid-proof brick. Crystallizers operating at lower temperatures are rubber lined. Bird centrifugals are of Monel. Evaporator tubes, tube sheets, part of the heater shells and vapor piping and the

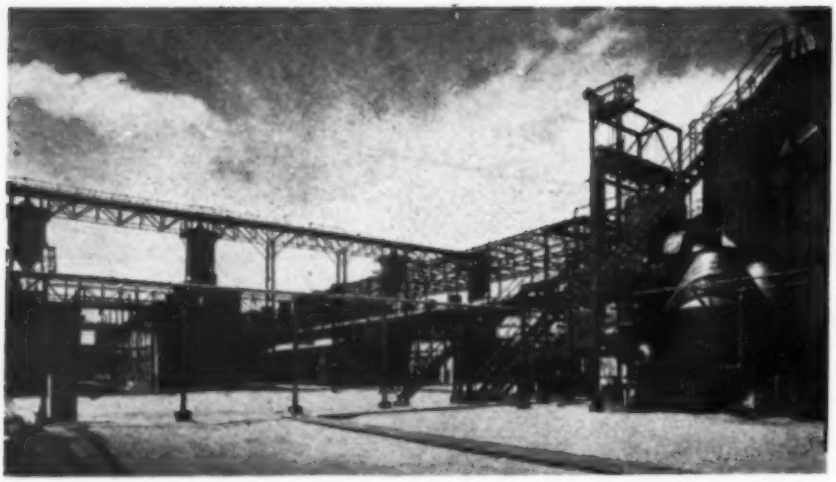


Fig. 6—Storage silos and conveyors for the magnesium chloride cell feed at Austin, Tex.

spray dryer atomizers are of Inconel. Control of evaporators is attained automatically, the actuating operation being by means of the boiling point rise of the solutions.

OPERATIONS AT AUSTIN

Magnesium chloride cell feed shipped from the Austin plant forms only a part of that fed to the electrolytic cells at Austin. The amount required depends on the losses of chlorine and other process materials.

In the operation of the magnesium cells, the gases evolved contain a mixture of chlorine and hydrochloric acid totaling approximately 5 percent. These gases are processed in a plant designed in accordance with the Dow system originally used at Midland, Mich. The hydrochloric acid is first removed by scrubbing with water, then the chlorine is converted to hydrochloric acid in a regenerative converter by reaction with water gas, the acid so formed being removed by water. The hydrochloric acid is produced as approximately 20 percent acid, but because the chlorine recoveries obtained at Austin are over 90 percent, the equipment is at present being modified to produce acid of a higher concentration. This will permit a lower cost from its use because of less water in the solution of magnesium chloride obtained by neutralizing magnesium hydroxide further on in the process; or the stronger acid may be available as a saleable product.

Magnesium hydroxide is produced at Austin from selected dolomite, quarried at Burnett, Texas, and shipped to Austin for calcining in a Smidth rotary kiln. The burned dolomite is slaked in a Dorr continuous slaker and the resulting slurry is fed continuously to two series of three Turbo-mixer carbonators. Each of these is fed with gas from the dolomite kiln which has been scrubbed with water to cool and clean it. Water scrubbing has not been found entirely satisfactory for this cleaning and a Cottrell precipitator is now being installed. The gas then enters Elliott turbo-compressors and is delivered to the carbonators at about 5 lb. pressure.

The carbonation process is highly efficient and although provision was originally made for using the stack gases from the boiler plant in case of emergency, this has not been found necessary. Carbonation proceeds until the calcium is entirely changed to the carbonate, control being effected automatically by electrical conductivity of the slurry.

At this point the slurry is passed through Bird centrifugal filters which remove a portion of the water, the resulting cake passing to the neutralizing section where, in Turbo-mixer tanks, the magnesium chloride is neutralized with hydrochloric acid. There results a slurry of calcium carbonate suspended in a solution of magnesium chloride and the carbonate is removed by filtration.

The magnesium chloride solution is concentrated by means of a battery of Ozark submerged combustion evaporators to a content of approximately 34 percent magnesium chloride. At this point the residual calcium is removed as calcium sulphate and the solution concentrated and dehydrated to $MgCl_2.1\frac{1}{2}H_2O$ in a standard Dow-designed equipment.

CREDIT AND ACKNOWLEDGMENT

In an article of this kind it is difficult to bestow credit adequately to all who have participated in the development. The processes in use at Carlsbad and Austin were conceived in the Research Division of International Minerals & Chemical Corp. and in the case of the magnesium chloride process, much of the credit is due to the work of W. E. Burke and W. A. Smith. Pilot plant work was carried out at Carlsbad with the help of R. A. Lindsay and A. J. Barnebl; W. L. Badger acted as consultant in the pilot plant work and on the design of the evaporators. Dr. Colin G. Fink participated as a consultant on the project. Credit for the development of the dolomite process at Austin is shared with H. Lundin, and H. H. Cudd, among others in the Research Division. Pilot plant work was carried on at the Westport laboratory of the Dorr Co. largely under the direction of C. L. Knowles. All of the final design and construction work of both plants was in charge of James A. Barr, chief engineer of International, and the Austin Co. of Cleveland were the erecting contractors.

In charge of the entire project is James P. Margeson, Jr., Vice President of International. The plant operations at Carlsbad are supervised by H. S. Martin, George T. Harley and John Burrows. At Austin the operations are in charge of William B. Leach.

Louis Ware, president of International Minerals & Chemical Corp., has aptly summarized the broad economic significance of the Carlsbad-Austin development in these works: "This enterprise has demonstrated the feasibility of recovering the entire ultimate values in products from ore mined in New Mexico from government-owned land, the production of muriate of potash, sulphate of potash, magnesium metal and hydrochloric acid from Carlsbad ores, leaving only the common salt and dirt from the ore as unused products."

How Magnesium Is Used

WPB revealed Mar. 22 that shipments of fabricated magnesium products doubled in 1943 as compared with the 78,000,000 lb. so used in 1942. This increase reflects the rising demands of the aircraft program where over 90 percent of the fabricated magnesium is used. Although data on incendiary bomb castings were not revealed, it was said that shipments of this single type of permanent mold casting exceeded shipments of all other kinds of fabricated magnesium combined.

The rate of increase has been most marked in forgings and permanent mold castings (other than bombs) where quarterly shipments at the end of 1943 were more than 1,000 percent greater than those at the beginning of 1942.

Shipments of sand castings, from the tonnage standpoint the most important of the magnesium products, trebled from the beginning of 1942 to the end of 1943. Virtually all of this product is heat-treated for increased strength and goes into engine, wheel, and other aircraft parts.

On the same day the Chemical Warfare Service revealed construction of its new 500 lb. "blockburner" incendiary bomb, known also as the M-76 or "goop" bomb. This tremendously destructive fire agent contains a mixture of jellied oil and finely powdered magnesium which cannot be extinguished once it starts blazing. It has already been used in a number of the European raids.

CHEM & MET REPORTS ON

Production, Application and TRANSFER OF HEAT

HEAT TRANSMISSION, or rather the broader term, "heat technology," which includes the production of heat and cold in addition to the transfer of heat energy, is the most nearly universal of all unit operations of chemical engineering. In fact it enters as a constituent part of many other unit operations and most of the unit processes. This importance has been so thoroughly appreciated in recent years that a large part of all fundamental chemical engineering research has been directed toward the better understanding of heat flow.

Nevertheless, heat transfer is not yet an exact science. Most of the subject is clearly understood from a qualitative standpoint, but large areas of it, especially in the fields of fluid convection and radiation, do not yield to precise quantitative calculation. The determining factors are known but their relations are often extremely complex. Much progress has been made, however, especially through the use of dimensional analysis which has suggested the form that theoretical equations should take, leaving the determination of numerical constants to experiment. A considerable number of these equations have proved valuable for correlating experimental data and when used intelligently, together with factors of experience, enable the user to predict results within reasonable limits of engineering accuracy.

While the science has been going forward, its tools have also been improved. Complex mathematics has often made the solution of particular problems difficult or even impossible. Mathematical techniques have now yielded usable approximation methods, and electrical analogies embodied in Columbia University's heat and mass flow analyzer now permit the solution of any problem in conduction or convection for which adequate data can be provided.

Not since 1932 has *Chem. & Met.* attempted a broad study of the heat technology theme. Unfortunately 1944's effort encounters the problem of the paper shortage and the need for limiting this special section to 32 pages in contrast with the 48 or more pages customary in our Spring technical issues. Large parts of the general theme have necessarily been omitted, or merely saluted in passing, including the whole subject of thermal insulation, and most of what might have been included on interfuel competition, combustion, furnaces and refrigeration. Many special cases of heat transfer, too, have been omitted, and for these the reader must refer to the literature.

Since space is lacking for a broader coverage, the approach chosen is a concentrated attack on four fundamental phases of the theme: (1) The general theory, briefed down for ready use, with the emphasis on a new and more convenient method of determining convection coefficients; (2) the production and application of heat and cold, emphasizing the heat transfer conditions encountered in principal types of application; (3) media that are used or might be used for heat transfer; and (4) the equipment of heat transfer, with a discussion of the place of heat transfer in unit operations equipment intended primarily for another purpose.

We of *Chem. & Met.* wish particularly to record appreciation for the thorough-going cooperation given by the contributors to this special section. In spite of the extra demands of wartime, all of them devoted many hours to their tasks. If their efforts help to smooth the path for readers who wish to enter the extensive literature, or even supplant the latter for those who require only a brushing up or a passing acquaintance with the subject, they will have accomplished their full purpose.

HEAT TRANSFER

Conduction, Radiation and Convection

HERMAN J. STOEVER
Associate Professor of Mechanical Engineering
Iowa State College, Ames, Iowa

MANY PROBLEMS in heat transfer are complex and can be solved only by involved mathematics or by experiment. Fortunately, satisfactory solutions for many practical problems can be obtained by means of fairly simple equations. It is the purpose of this article to list the more important of these simple equations and to explain briefly their derivation and use. Tables and nomographs are also presented by means of which convection coefficients for a number of fluids under various conditions can be quickly and easily determined.

The three methods by which heat may be transferred are conduction, radiation, and convection. Conduction is the transfer of heat from one particle of matter to another, the particles remaining in fixed positions relative to each other. Radiation is the transfer of heat from one body to another as the result of the emission and absorption of a form of energy called radiant energy. Convection is the transfer of heat from one part of a fluid to another by mixing the warmer particles of the fluid with the cooler. If the motion of the fluid is caused entirely by differences in density within the fluid, it is called natural convection; if the motion is caused by some mechanical means such as a stirrer, pump, fan or blower, it is called forced convection.

All three methods of heat transfer are likely to be involved in any practical problem, and consequently, in order to design heat transfer equipment, it may be necessary to calculate the rate at which heat is transferred by each. It frequently happens, however, that even though all three methods may be involved, the rate of heat transfer by one of the methods is small and may be neglected.

CONDUCTION

There are two general types of conduction, known as steady and unsteady conduction. If the temperature at each point in a body remains constant, the rate of heat transfer through the body remains constant and the conduction is said to be steady. If the temperature at any point varies, the rate of heat transfer will not remain constant, and the conduction is said to be unsteady. For example, when steam is admitted to a pipe covered with insulation the temperature at the inside surface of the pipe quickly approaches the temperature of the steam, while the temperature at the outside surface of the insulation at first remains unchanged. Eventually, however, the temperature at every point throughout the insulation reaches an equilibrium value. Until these equilibrium temperatures are reached, the conduction of heat through the insulation is unsteady; after they have been reached, the conduction is steady.

The rate at which heat flows through any material by either steady or unsteady conduction is calculated by making use of a property of the material known as its thermal conductivity. This property, denoted by the symbol k, is defined as the rate at which heat is conducted through the material per unit cross sectional area taken normal to the direction of heat flow and per unit temperature gradient taken in the direction of heat flow. Thus,

$$k = \frac{q}{A\left(-dt/dL\right)}, \qquad (1)$$

where q denotes the rate of heat flow normal to any isothermal surface, A denotes the area of the surface, and $-dt/dL$ denotes the temperature gradient in the direction of heat flow. The minus sign is necessary because the temperature decreases in the direction of heat flow.

The thermal conductivity of any material must be determined by experiment. For practically all materials it depends upon the temperature; for some increasing with an increase in temperature, and for others decreasing. With most materials this variation is practically linear over a considerable range of temperature. Pressure has a negligible effect on the thermal conductivity over the range ordinarily encountered in engineering work. Values of the thermal conductivity of most materials of industrial importance can be found in handbooks or any book devoted to heat transfer.

Chem. & Met. wishes to acknowledge its indebtedness to the McGraw-Hill Book Co., Inc. for permission to brief a considerable part of the material included in the first half of Prof. Stoever's text, "Applied Heat Transmission" (McGraw-Hill 1941). In particular, the section on film coefficients, pp. 102 to 105, is somewhat similar to and derived from the same data as Chap. IV of Prof. Stoever's text. The method employed here is a new modification developed for us by Prof. Stoever and better adapted to compact presentation, but not quite so broadly applicable. Several of the cases in the original work have necessarily been omitted.

The units of k depend upon the units chosen for q, A, and dt/dL. Thus, if q is measured in B.t.u. per hour, A in square feet, and dt/dL in deg. F. per foot, the units of k are

$$\frac{\text{B.t.u./hr.}}{\text{(sq.ft.) (deg. F./ft.)}} = \frac{\text{B.t.u.}}{\text{(ft.) (hr.) (deg. F.)}}.$$

Values of k expressed in the units B.t.u./(hr.) (sq.ft.) (deg. F./in.) can be converted to the units B.t.u./(ft.) (hr.) (deg F.) by dividing them by 12.

Equation (1) may be written

$$q = -kA\frac{dt}{dL}. \qquad (2)$$

This is the fundamental equation for unidirectional heat transfer by conduction and is known as Fourier's Law. In order to apply it to the solution of practical problems, the equation must be integrated.

For steady conduction q remains constant and Eq. (2) can be integrated, if the area A of the isothermal surfaces existing within the body can be expressed as a function of the distance L to these surfaces, and if the thermal conductivity k is expressed as a function of the temperature t. This can be done easily only if the area A is a simple function of the distance L, as in the case of plane walls, cylindrical walls, or spherical walls.

For example, consider a body having cylindrical walls, such as the insulation on pipes. If the inside and outside surfaces of the insulation are assumed to be at uniform temperatures, all the isothermal surfaces will be concentric cylinders, and the area of each of them will be $2\pi Ll$, where L is the radius of the surface and l is its length. Introducing this expression for A into Eq. (2) and rearranging,

$$\frac{q}{2\pi l}\cdot\frac{dL}{L} = -kdt.$$

On integrating between the limits $L = r_1$ and $L = r_2$, the left side of this equation becomes $(q/2\pi l)\ \ln\ (r_2/r_1)$. If k varies linearly with the temperature, it can be shown that integrating the right side of the equation will yield $k_{av}(t_1-t_2)$, where k_{av} is the value of k at the average of temperatures t_1 and t_2. Hence, equating these two expressions and rearranging,

$$q = \frac{k2\pi l\ (t_1 - t_2)}{\ln\ (r_2/r_1)}.$$

Similar integrations can be carried out for plane or spherical walls. The resulting

Table I—Steady Conduction Equations

Plane walls:

$$q = \frac{kA(t_1 - t_2)}{L} \quad (3)$$

Cylindrical walls:

$$q = \frac{k\,2\pi l(t_1 - t_2)}{2.3 \log_{10}(r_2/r_1)} \quad (4)$$

Spherical walls:

$$q = \frac{k\,4\pi r_1 r_2 (t_1 - t_2)}{r_2 - r_1} \quad (5)$$

Composite plane walls (Two or more materials in series):

$$q = \frac{A(t_1 - t_2)}{(L_a/k_a) + (L_b/k_b) + (L_c/k_c)} \quad (6)$$

Composite cylindrical walls:

$$q = \frac{2\pi l(t_1 - t_2)}{2.3\left[\frac{\log_{10}(r_a''/r_a')}{k_a} + \frac{\log_{10}(r_b''/r_b')}{k_b}\right]} \quad (7)$$

Nomenclature: q = the rate of heat transfer by conduction, B.t.u. per hr.
k = the thermal conductivity of the wall at the average of temperatures t_1 and t_2, B.t.u./(ft.) (hr.) (deg. F.)
k_a, k_b, and k_c = the thermal conductivities of materials a, b, and c, evaluated at the average temperature of each, B.t.u./(ft.) (hr.) (deg. F.)
A = the area of the wall, sq. ft.
t_1 and t_2 = the temperatures at the inside and outside faces, deg. F.
L = the thickness of the wall, ft.
L_a, L_b, and L_c = the thicknesses of materials a, b, and c, ft.
l = the length of the cylinder, ft.
r_1 and r_2 = the radii of the inside and outside faces respectively, ft.
r_a' and r_a'' = the radii of the inside and outside faces of material a, ft. or in.
r_b' and r_b'' = the radii of the inside and outside faces of material b, ft. or in.

equations, together with equations for composite plane or cylindrical walls, are listed in Table I.

For unsteady conduction, the rate of heat transfer q does not remain constant, and the integration of Eq. (2) becomes quite difficult. Simple methods of solving problems involving certain kinds of unsteady conduction may be found in various heat transfer books.

RADIATION

Radiant energy is emitted by all matter and consists of electromagnetic waves of a number of different wave lengths. It obeys the same laws as light and does not require the presence of any matter for its transmission. On encountering any matter, radiant energy may be absorbed and converted into heat, it may be transmitted through the matter, or it may be reflected. For example, radiant energy incident upon a brick wall is partly absorbed and partly reflected; radiant energy incident upon dry air is largely transmitted through the air; and radiant energy falling upon a highly polished metal surface is largely reflected.

The rate at which radiant energy is emitted by any solid body depends upon the temperature of the body and upon the nature of the surface of the body. Thus, it has been found experimentally, (a) that the rate of emission from a given surface increases as its temperature is increased, and (b) that various surfaces all at the same temperature emit radiant energy at different rates but there is a maximum rate which none exceeds.

The hypothetical body whose surface absorbs all the radiation falling upon it is called a black body. Such a body also has the important property of emitting radiation at the maximum possible rate. The ratio of the rate at which any actual body emits radiation to the rate at which a black body at the same temperature would emit radiation is called the emissivity of the body. Similarly, the ratio of the amount of radiant energy absorbed by any body to the amount which a black body would absorb is called the absorptivity of the body. These two terms may be thought of as the "efficiency" of the body so far as its ability to emit or absorb radiation is concerned. It can be shown that the emissivity and the absorptivity of any body are numerically equal. Values of the emissivities of many surfaces can be found in handbooks or in any heat transfer book.

The rate at which radiation is emitted by a black body (that is, the maximum possible rate at any given temperature) is given by the equation

$$q = 0.173 \times 10^{-8} A T^4, \quad (8)$$

where q = the rate of emission, B.t.u. per hr.; A = the area of the body, sq. ft.; and T = the absolute temperature of the body, deg. F. abs. This is the fundamental equation for heat transfer by radiation and is known as the Stefan-Boltzmann equation.

It follows from Eq. (8) and from the definition of emissivity that the rate at which radiation is emitted by any actual body is given by the equation

$$q = 0.173 \times 10^{-8} A T^4 e,$$

where e denotes the emissivity of the body. This is not the *net rate* of heat transfer by radiation, however, because the body is simultaneously receiving radiation from its surroundings. The net rate of heat transfer by radiation from any body is qual to the rate at which the body emits radiation, minus the rate at which it reabsorbs the fraction of this radiation that is reflected back to it by the surrounding surfaces, and minus the rate at which it absorbs the radiation emitted by the surroundings. It is evident that the net rate of heat transfer by radiation depends not only upon the temperature and emissivity of the body but also upon the temperature and emissivity of the surroundings.

It can be shown that if any isothermal surface (1) is completely enclosed by another isothermal surface (2) and is separated from it by a nonabsorbing medium such as dry air, the net rate at which heat is transferred by radiation between the two surfaces can be calculated by

$$q = 0.173 A_1 \left[\left(\frac{T_1}{100}\right)^4 - \left(\frac{T_2}{100}\right)^4\right] F_e, \quad (9)$$

where q = the net rate at which heat is transferred from surface (1) to surface (2) by radiation, B.t.u. per hour; A_1 = the effective area of surface (1) calculated as explained in the following paragraph, sq. ft.; T_1 and T_2 = the absolute temperatures of surfaces (1) and (2), deg. F. abs. (= deg. F. + 460); and F_e = a factor to allow for the emissivities of the two surfaces, determined from Table II.

The effective area of any surface is equal to the actual area, unless the surface

Table II—Emmisivity Factor F_e. (e_1 and e_2 denote the emissivities of surfaces *1* and *2*)

No.	Type of surface	F_e
1	Surface *1* of any shape but small compared to surface *2*.	e_1
2	Surface *1* of any shape but almost as large as surface *2*.	$\frac{1}{\frac{1}{e_1} + \frac{1}{e_2} - 1}$
3	Surface *1* either of two infinite parallel planes.	$\frac{1}{\frac{1}{e_1} + \frac{1}{e_2} - 1}$
4	Surface *1* the smaller of two concentric cylinders of radii r_1 and r_2 and of infinite length.	$\frac{1}{\frac{1}{e_1} + \frac{r_1}{r_2}\left(\frac{1}{e_2} - 1\right)}$
5	Surface *1* the smaller of two concentric spheres of radii r_1 & r_2.	$\frac{1}{\frac{1}{e_1} + \left(\frac{r_1}{r_2}\right)^2\left(\frac{1}{e_2} - 1\right)}$

contains concave portions, such as dimples or grooves. In the latter case, the effective area is less than the actual area and may be taken as approximately equal to the area of the surface that would be obtained if all the grooves and dimples were filled up flush with the adjacent plane or convex portions of the surface.

If surface (2) does not completely inclose surface (1), the net rate of heat transfer by radiation can be calculated by adding another factor F_A to Eq. (9) to allow for the fact that all the radiation from surface (1) does not fall upon surface (2). Graphs which can be used to determine the factor F_A for a number of conditions have been prepared by Hottel. (*Mech Eng.*, vol. 52, p. 699, 1930.) For a discussion of radiation from gases and from clouds of particles, the reader is referred to pages 64 to 86 of McAdams' "Heat Transmission." (McAdams, W. H., "Heat Transmission," McGraw-Hill Book Co., Inc., New York, 1942).

CONVECTION

Convection Between a Fluid and its Retaining Wall—The rate at which heat is transferred by convection from a retaining wall to a fluid in contact with the wall is calculated by means of so-called film coefficients (also called surface coefficients or individual coefficients. These coefficients, denoted by the symbol h, are defined as the rate at which heat is transferred from the wall to the fluid per unit area of the retaining wall and per degree temperature difference between the surface of the wall and the main body of the fluid. From this definition, it follows that

$$q = hA\,(\Delta t), \quad (10)$$

where q = the rate of heat transfer by convection, B.t.u. per hour; h = film coefficient, B.t.u./(sq.ft.) (hr.) (deg. F.); A = the area of the retaining wall, sq.ft.; and Δt = the temperature difference between the surface of the wall and the main body of the fluid, deg. F.

Film coefficients depend upon a number of factors. For all types of convection they depend not only upon the kind of fluid involved and upon the pressure and

temperature of the fluid, but also upon the type of retaining wall (e.g., flat surfaces, tubes, etc.) and upon the position of the retaining wall (e.g., horizontal or vertical). In addition, if the fluid remains a liquid or a gas, the film coefficients depend upon the turbulence of the fluid and increase as the turbulence increases. In the case of natural convection, the turbulence, and consequently the film coefficient, increases as the temperature difference between the main body of the fluid and the surface of the retaining wall increases. In the case of forced convection, the film coefficients for turbulent flow are much larger than for streamline flow. For flow outside tubes, the film coefficients depend upon the direction of flow. For any given velocity, the film coefficients for flow normal to tubes are usually higher than for flow parallel to tubes. The film coefficients depend also upon whether the fluid is being heated or cooled.

If condensation takes place, the film coefficients depend upon whether the condensation is dropwise or filmwise. In dropwise condensation the condensate forms in drops on the surface of the retaining wall and does not wet the entire wall, whereas in filmwise condensation the condensate forms a continuous film over the entire surface. Film coefficients for dropwise condensation are likely to be from 10 to 20 times as large as those for filmwise condensation, but it is rather an unstable phenomenon and probably does not occur very frequently in practice. Any condensate adhering to the retaining wall acts as insulation, and anything which will decrease the thickness of the layer will cause the film coefficient to increase. Thus, if the vapor to be condensed sweeps over the retaining wall and carries away part of the condensate film, the film coefficient is increased.

Film coefficients for boiling depend upon how great a fraction of the wall is in contact with the liquid rather than with its vapor. Thus, if the vapor bubbles formed at the heating surface are small and break away from the surface quickly, a larger fraction of the surface will be in contact with the liquid, and consequently the film coefficient will be larger. Anything which will tend to keep the size of the vapor bubbles formed small or which will cause these bubbles to break away from the surface more quickly will increase the film coefficient. For example, if the liquid is violently stirred, the vapor bubbles will break away more quickly, and the film coefficient will be increased.

Tables and nomographs for determining film coefficients for various fluids under various conditions are given on pages 102 to 105 of this article. The method of using these tables and nomographs, together with the use of the equations for steady flow conduction and for radiation, is illustrated in the following problem:

FLUID-WALL EXAMPLE

Illustrative Problem 1—A 3-in. horizontal pipe (3.500 in. O. D.) is covered with 1 in. of insulation having a thermal conductivity of 0.042 B.t.u./(ft.)(hr.)(deg. F.). If the temperature of the pipe is 400 deg. F. and the temperature of the surrounding air is 70 deg. F., calculate the heat loss from the pipe per foot of length.

Solution—The rate of heat transfer through the insulation by conduction is equal to the sum of the rates at which heat is lost from the outside surface of the insulation by radiation and by convection. The rate of heat transfer by conduction can be determined by Eq. (4), the rate by radiation by Eq. (9) (with $F_e = e_1$ since the pipe is small compared to its surroundings), and the rate by convection by Eq. (10). Hence, letting t_s denote the temperature of the outside surface of the insulation and assuming $e_1 = 0.90$.

$$\frac{0.042 \times 2\pi \times 1 \times (400 - t_s)}{2.3 \log_{10} (2.750/1.750)} =$$

$$= 0.173 \times \frac{2\pi \times 2.750}{12}\left[\left(\frac{t_s + 460}{100}\right)^4 - \left(\frac{530}{100}\right)^4\right] \times 0.90$$

$$+ h \times \frac{2\pi \times 2.750}{12}(t_s - 70).$$

Since the film coefficient h for air heated outside single horizontal cylinders by natural convection depends upon the temperature difference between the surface of the cylinder and the air, a trial-and-error solution is necessary. If, as a first trial, t_s is assumed to be 130 deg. F., the film temperature will be (70+130)/2=100 deg. F., the corresponding value of h, = 0.88 B.t.u./(sq.ft.) (hr.) (deg. F.), the value of $\Delta t/D = (130 - 70)/5.500 = 10.9$, the corresponding value of $F = 1.02$, and finally $h = 0.88 \times 1.02 = 0.90$ B.t.u./(sq.ft.)(hr.)(deg. F.). Substituting this value of h and $t_s = 130$ deg. F. into the foregoing equation, the left side is found to equal 713 B.t.u. per hr., and the right side, 768 B.t.u. per hr. The equation is not satisfied and a second trial must be made. If t_s is assumed to be 127 deg. F., both sides of the equation are found to equal 722 B.t.u. per hr., and therefore this is the rate of heat loss from the pipe per foot of length.

An interesting fact is that the rate of heat loss from the surface of the insulation by radiation is greater than by convection.

Convection Between Two Fluids Separated by a Retaining Wall—In most industrial heat transfer equipment, one fluid receives heat from another fluid, the two fluids being separated by a solid retaining wall. In designing such equipment, the temperature at which the two fluids are to enter and leave the equipment are usually known, but the temperature of the retaining wall is not known. Consequently, the expected rate of heat transfer cannot be calculated directly from the film coefficients, since these are based on the temperature difference between the retaining wall and the fluids. However, the expected rate of heat transfer can be readily calculated from the so-called overall coefficient U because this coefficient is based on the temperature difference between the two fluids.

The overall coefficient U is defined as the rate at which heat is transferred from one fluid to another per unit area of the retaining wall and per degree temperature difference between the two fluids. From this definition, it follows that

$$q = UA\,(\Delta t) \qquad (11)$$

where q = the rate of heat transfer by convection, B.t.u. per hr.; U = the overall coefficient, B.t.u./(sq.ft.)(hr.)(deg. F.); A=the area of the retaining wall, sq.ft.; and Δt = the temperature difference between the main body of the one fluid and the main body of the other, deg. F.

The amount of heat transfer surface required in any equipment in which heat is to be transferred from one fluid to another by convection can be calculated by Eq. (11). It is necessary first to determine (1) the rate q at which heat is to be transferred from one fluid to the other, (2) the overall coefficient of convection U, and (3) the mean temperature difference Δt between the two fluids. These three quantities can be determined as follows:

1. If the equipment is to be insulated, the rate of heat transfer q can be calculated from the properties of either fluid because the rate at which the warmer fluid will give up heat must equal the rate at which the cooler fluid will absorb heat. If the fluid used in the calculation does not change phase, the rate of heat transfer q can be calculated from the rate of flow, the specific heat, and the entering and leaving temperatures of the fluid. If the fluid evaporates or condenses, the rate of heat transfer q can be calculated from the rate of flow and the heat of vaporization of the fluid.

It may be noted that the temperatures and rates of flow of the two fluids may not all be chosen arbitrarily because (*a*) the values must be such that the heat balance is satisfied, and (*b*) at every section of the equipment the temperature of the warmer fluid must be higher than the temperature of the cooler fluid.

2. The overall coefficient U can be calculated from the film coefficients for the two fluids by means of the equations listed in Table III. These equations are based on the following facts: (*a*) the sum of the temperature differences between each fluid and the retaining wall, plus the temperature drop through the wall itself, is equal to the total temperature difference Δt between the two fluids; and (*b*) the rate of heat transfer by convection from the

Table III—Relation Between the Over-All Coefficient *U* and the Film Coefficients

Flat or slightly curved walls, free from scale:

$$\frac{1}{U} = \frac{1}{h_1} + \frac{L}{k} + \frac{1}{h_2} \qquad (12)$$

Thin-walled tubes, free from scale:

$$\frac{1}{U} = \frac{D_2}{h_1 D_1} + \frac{L}{k} + \frac{1}{h_2} \qquad (13)$$

Thick-walled tubes, free from scale:

$$\frac{1}{U} = \frac{D_2}{h_1 d_1} + \frac{D_2}{2k} \times \log_e\left(\frac{D_2}{D_1}\right) + \frac{1}{h_2} \qquad (14)$$

Nomenclature:

- U = the over-all coefficient, B.t.u./(sq.ft.) (hr.) (deg. F.). For tubes, the value of U will be based on the *outside* surface of the tubes; that is, the heat transfer surface A, calculated by Eq. (11), will be the *outside* tube surface required.
- h_1 = the film coefficient for one side of the flat wall or for the *inside* of the tube, B.t.u./(sq.ft.) (hr.) (deg. F.)
- h_2 = the film coefficient for the other side of the flat wall or for the *outside* of the tube, B.t.u./(sq.ft.) (hr.) (deg. F.).
- L = the thickness of the wall, ft.
- k = the thermal conductivity of the wall, B.t.u./(ft.) (hr.) (deg. F.)
- D_1 = the inside diameter of the tube, ft.
- D_2 = the outside diameter of the tube, ft.

warmer fluid to the wall, the rate of heat transfer by conduction through the wall, and the rate of heat transfer by convection from the wall to the cooler fluid are all equal. The rates of heat transfer from each of the fluids to the wall are given by Eq. (10), and the rate of heat transfer by conduction through the wall is given by Eq. (3) or (4). Eliminating q and the temperature difference terms from these equations and Eq. (11) will yield Eqs. (12), (13), and (14).

The overall coefficient U can be readily calculated by means of the equations listed in Table III, provided the film coefficients for the two fluids are known. Examination of the tables and nomographs on pages 102 to 105 will show that many of the film coefficients depend, however, either upon the temperature difference between the surface of the retaining wall and the main body of the fluid, or upon the film temperature t_f, which is arbitrarily defined as the arithmetic average of the temperature of the surface of the retaining wall and the temperature of the main body of the fluid. In order to evaluate either of these quantities, the temperature of the surface of the retaining wall must be known. Sufficiently accurate results can frequently be obtained by assuming some value that appears reasonable for this temperature. If more accurate results are desired, the exact temperature can be calculated by trial-and-error as follows: Neglecting the temperature drop through the wall itself, a tentative value is assumed for the temperature t_w of the wall. Next, the film coefficients h_1 and h_2 corresponding to this value are determined from the tables and nomographs. Using these values of h_1 and h_2, a more accurate value of t_w is calculated by the equation

$$t_w = \frac{h_1 t_1 + h_2 t_2}{h_1 + h_2} \qquad (15)$$

where t_1 and t_2 are the temperatures of the main bodies of the two fluids. This value of t_w will usually be sufficiently accurate for practical purposes, and the final values of h_1 and h_2 can be determined by using it.

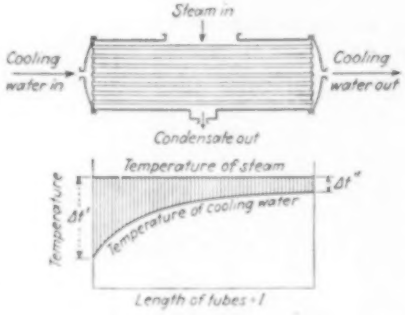
The equation listed in Table III are applicable if the retaining wall is free from scale. If scale is present on either surface, the overall coefficient can be calculated by the equation

$$\frac{1}{U_s} = \frac{1}{U_c} + \frac{1}{h_s} \qquad (16)$$

where U_s = the overall coefficient when one surface of the retaining wall is covered with scale, B.t.u./(sq.ft.)(hr.)(deg. F.); U_c = the overall coefficient when both surfaces of the retaining wall are clean, B.t.u./(sq.ft.)(hr.)(deg. F.); and h_s = the scale coefficient, B.t.u./(sq.ft.)(hr.)(deg. F.), which is defined as the rate of heat transfer through the scale per unit area of scaly surface and per degree temperature drop through the scale. If scale is present on both surfaces, a second $1/h_s$ term must be added to the equation.

Regarding the choice of velocities to be used in designing heat transfer equipment, high fluid velocities are desirable because the film coefficients are higher at high velocities than at low. As a result, less heat transfer surface is required, and the cost of the equipment is less. On the other hand, the pressure drop through the equipment is also greater at high velocities, and this increases the cost of pumping. The optimum design is the one for which the sum of the annual charges on the equipment, plus the yearly cost of the power to operate it, is a minimum.

Fig. 1—Variation of the temperature difference in a condenser



3. The temperature difference Δt to be used in Eq. (11) must be the *mean* temperature difference between the main body of the one fluid and the main body of the other. In general, the temperature difference between the two fluids flowing through any kind of heat transfer equipment does not remain constant throughout the equipment. For example, consider a steam condenser in which the cooling water makes a single pass through the tubes, as shown in Fig. 1. The temperature difference $\Delta t'$ between the cooling water entering the condenser and the condensing steam is larger than the temperature difference $\Delta t''$ between the cooling water leaving the condenser and the condensing steam. Consequently, the rate of heat transfer is larger where the cooling water enters the condenser and, as a result, the temperature rise of the cooling water is more rapid at first than it is later. It is evident from Fig. 1 that the mean temperature difference between the two fluids is not the arithmetic average of $\Delta t'$ and $\Delta t''$, but instead is the average height of the shaded area shown. For the conditions described this average value is called the logarithmic-mean temperature difference and can be calculated by the equation

$$\Delta t_{l.m.} = \frac{\Delta t' - \Delta t''}{2.3 \log_{10} (\Delta t'/\Delta t'')} \qquad (17)$$

where $\Delta t_{l.m.}$ = the logarithmic-mean temperature difference, deg. F.; $\Delta t'$ = the greater terminal temperature difference, deg. F.; and $\Delta t''$ = the smaller terminal temperature difference, deg. F.

If the ratio of $\Delta t'/\Delta t''$ is less than two, the arithmetic mean of $\Delta t'$ and $\Delta t''$ will differ from the logarithmic mean by less than 4 percent. This approximation may frequently be used without introducing any serious error.

The average difference in temperature between two fluids flowing through any kind of heat transfer equipment will equal the logarithmic-mean temperature difference if (*a*) the equipment is perfectly insulated, (*b*) the overall coefficient U is constant throughout the equipment, (*c*) the specific heat and weight rate of flow of each fluid is constant, unless the fluid is evaporating or condensing, and (*d*) either the fluids flow through the equipment in parallel paths or the temperature of one of them remains constant. The direction of flow is immaterial, the equation being valid whether the two fluids flow in the same direction (parallel flow) or in opposite directions (counter-flow).

Provided that the first three conditions are satisfied, the logarithmic-mean temperature difference will be approximately correct for single-pass heat exchangers with or without cross baffles in the shell and for condensers regardless of the number of passes made by the cooling fluid. For multipass heat exchangers the true mean temperature difference can be determined by multiplying the logarithmic-mean temperature difference calculated for counter-flow by a correction factor. Values of this correction factor for different conditions are given by Bowman, Mueller, and Nagle. (*Trans.* A.S.M.E., vol. 62, p. 283, 1940.)

The procedure, discussed in the foregoing section, which may be used in designing equipment involving heat transfer by convection between two fluids, is illustrated by the following problem:

FLUID-FLUID EXAMPLE

Illustrative Problem 2—A flow of 100 cu.ft. of free air per minute, compressed to a pressure of 50 lb. per sq.in. gage, is to be cooled from 210 to 90 deg. F. in a coil submerged in water at 80 deg. F. How long must the coil be if it is made of 1¼-in. steel pipe bent into a 2-ft. diameter helix?

Data—Specific heat of air at constant pressure = 0.24 B.t.u./(lb.)(deg. F.); density of the free air = 0.075 lb. per cu.ft.

Solution—The weight of air flowing through the coil will be

$$100 \times 60 \times 0.075 = 450 \text{ lb. per hr.}$$

The required rate of heat transfer can be calculated from this value, the specific heat, and the temperature drop of the air:

$$q = 450 \times 0.24 \times (210 - 90)$$
$$= 13{,}000 \text{ B.t.u. per hr.}$$

The film coefficient h_1 for the air can be determined from the equation for gases flowing inside coils. Since the internal cross-sectional area of a 1¼-in. pipe is 1.495 sq.in., the weight velocity of the air

$$G = \frac{450 \times 144}{3{,}600 \times 1.495} = 12.0 \text{ lb./(sec.) (sq. ft.)}$$

From the table and nomograph, for gases heated or cooled inside tubes, $h_o = 4.00$ B.t.u./(sq.ft.)(hr.)(deg. F.) (at the average temperature of the air = 150 deg. F.), and $F = 6.8$ (inside pipe diameter = 1.38 in.). Hence, for the coil,

$$h_1 = \left[1 + 3.54\left(\frac{1.38}{24}\right)\right] \times 4.00 \times 6.8$$
$$= 32 \text{ B.t.u./(sq. ft.) (hr.) (deg. F.).}$$

The film coefficient h_2 for the water can be determined from the table and nomograph for liquids heated outside single horizontal tubes by natural convection. The average pipe wall temperature t_w must first be determined by Eq. (15). As a first trial, assume $t_w = 90$ deg. F. From the table, $h_o = 4.45$ B.t.u./(sq.ft.)(hr.)(deg. F.) (at $t_f = (90 + 80/2 = 85$ deg. F.), and from the nomograph, $F = 1.57$ ($\Delta t = 90 - 80 = 10$ deg. F., and the outside pipe diameter = 1.66 in.). Hence, as a first approximation,

$$h_2 = 44.5 \times 1.57 =$$
$$70 \text{ B.t.u./(sq. ft.) (hr.) (deg. F.).}$$

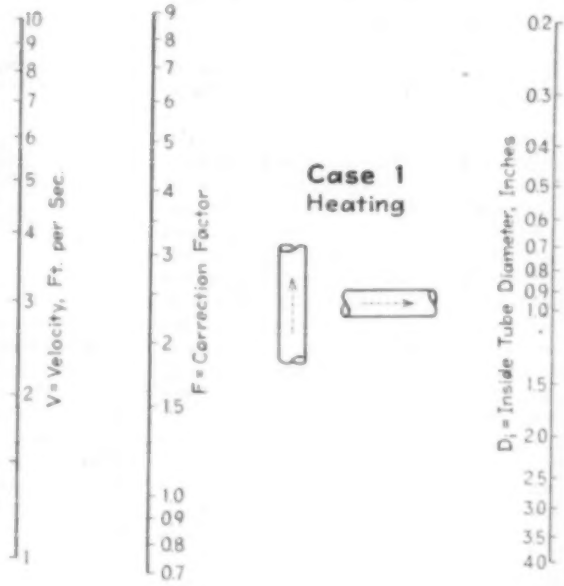
(*Continued on page 106*)

FILM COEFFICIENTS FOR LIQUIDS

To obtain the desired film coefficient, a base factor corresponding to the liquid and temperature under consideration is taken from the proper table and multiplied by a correction factor read from the nomograph accompanying that table. The following assumptions apply in each case: (1) The system is in equilibrium, that is, there is no change in temperature gradient with time; (2) radiation is negligible or has been taken into account by other calculations; (3) film temperature is defined as the arithmetic average of the temperatures of the retaining wall and the main body of the liquid. Wall temperature, generally not known, can be estimated or calculated by trial and error as described on page 101. Values of base factors in italics are extrapolated from physical properties.

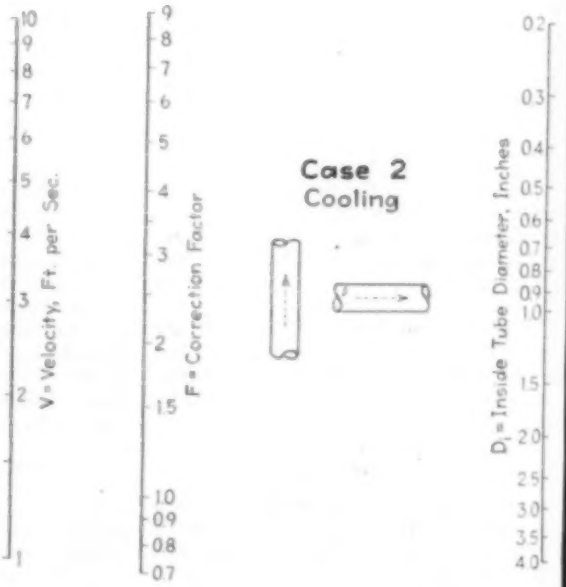
Case 1—Base Factors for Liquids Heated Inside Horizontal or Vertical Tubes, Turbulent Flow

	Average Temperature of the Liquid					
	0° F.	50° F.	100° F.	150° F.	200° F.	250° F.
Acetic acid (100%)	.....	.....	97.2	101	*105*	*109*
Acetic acid (50%)	.....	117	156	180	208	*238*
Acetone	*104*	122	134	137	*139*	*143*
Ammonia	350	425	507	*590*	*690*	*790*
Amyl acetate	65.0	66.2	67.7	71.8	*78.6*	*86.0*
Amyl alcohol (iso)	*81.6*	35.8	52.7	73.3	96.0	*118*
Aniline	.....	43.8	58.4	76.5	99.2	*125*
Benzene	.....	75.6	94.5	108	131	*154*
Brine ($CaCl_2$) (25%)	130	190	257	333	420	*517*
Butyl alcohol (n)	*81.9*	45.5	62.4	83.0	*107*	*135*
Carbon disulphide	114	119	125	129	*132*	*135*
Carbon tetrachloride	*87.4*	89.2	78.6	82.6	*85.6*	*88.9*
Chlorobenzene	*84.6*	73.3	78.6	80.5	82.0	*83.6*
Ethyl acetate	*136*	126	125	123	*122*	*121*
Ethyl alcohol (100%)	58.0	73.6	92.3	112	132	*151*
Ethyl alcohol (40%)	*61.6*	104	162	*208*	*258*	*309*
Ethyl bromide	*97.8*	104	110	114	*119*	*123*
Ethylene glycol	*71.4*	105	158	222	299	*380*
Ethyl ether	*100*	115	123	130	*137*	*144*
Glycerol (50%)	*59.0*	90.5	131	*189*	*248*	*302*
Heptane	*81.4*	87.0	94.7	102	*110*	*118*
Hexane	*86.8*	93.2	102	109	114	*117*
Methyl alcohol (100%)	*83.0*	110	126	*138*	*149*	*160*
Methyl alcohol (90%)	*86.0*	114	128	*154*	*179*	*188*
Methyl alcohol (40%)	*64.0*	110	164	213	*264*	*318*
Octane (n)	*78.0*	79.0	85.9	*89.0*	*97.0*	*108*
Pentane (n)	103	105	110	*115*	*118*	*121*
Propyl alcohol (iso)	*86.7*	49.3	71.5	94.5	*117*	*139*
Sulphur dioxide	167	171	175	*180*	*188*	*194*
Sulphuric acid (60%)	.....	65.9	79.4	94.5	*110*	*129*
Toluene	77.3	86.9	96.6	104	113	*119*
Water	.....	223	322	405	392	*608*



Case 2—Base Factors for Liquids Cooled Inside Horizontal or Vertical Tubes, Turbulent Flow

	Average Temperature of the Liquid					
	0° F.	50° F.	100° F.	150° F.	200° F.	250° F.
Acetic acid (100%)	.....	.....	72.2	75.0	78.7	*81.6*
Acetic acid (50%)	.....	85.2	122	153	179	*201*
Acetone	*88.4*	105	118	121	*124*	*126*
Ammonia	314	380	507	*650*	*797*	*938*
Amyl acetate	48.1	50.7	52.3	53.3	*54.4*	*55.5*
Amyl alcohol (iso)	.....	22.7	36.0	53.0	72.3	*91.8*
Aniline	.....	31.6	45.2	63.3	86.9	*110*
Benzene	.....	61.7	79.1	93.5	107	*120*
Brine ($CaCl_2$) (25%)	108	152	217	312	397	*510*
Butyl alcohol (n)	*19.9*	31.4	45.6	64.0	*84.9*	*107*
Carbon disulphide	103	110	116	121	*126*	*128*
Carbon tetrachloride	*49.4*	55.8	67.3	72.0	*76.0*	*79.7*
Chlorobenzene	*54.5*	57.5	60.7	63.8	65.0	*65.6*
Ethyl acetate	*53.2*	54.1	54.1	54.1	*55.3*	*57.4*
Ethyl alcohol (100%)	41.2	54.8	71.1	89.0	108	*128*
Ethyl alcohol (40%)	.....	70.4	121	*176*	*230*	*318*
Ethyl bromide	*84.9*	93.9	99.9	106	*112*	*116*
Ethylene glycol (50%)	*44.2*	71.7	120	183	261	.....
Ethyl ether	*98.0*	99.0	109	118	*126*	*134*
Glycerol (50%)	*54.9*	59.5	94.5	*124*	*170*	*222*
Heptane	*69.8*	74.2	81.5	88.8	*97.0*	*104*
Hexane	70.7	78.5	87.2	95.2	102	*108*
Methyl alcohol (100%)	*65.4*	88.5	105	*118*	*132*	*146*
Methyl alcohol (90%)	*68.5*	92.0	112	*128*	*142*	*156*
Methyl alcohol (40%)	*58.2*	80.0	127	177	*230*	*298*
Octane (n)	*56.0*	63.8	70.9	*77.2*	*83.2*	*88.0*
Pentane (n)	92.8	89.6	90.4	*101*	*106*	*110*
Propyl alcohol (iso)	.....	33.4	51.5	71.7	*92.7*	*116*
Sulphur dioxide	150	155	161	*166*	*174*	*178*
Sulphuric acid (60%)	.....	35.3	54.4	66.9	*74.0*	*77.7*
Toluene	61.8	71.5	81.4	90.3	97.6	*103*
Water	.....	153	273	355	427	*488*

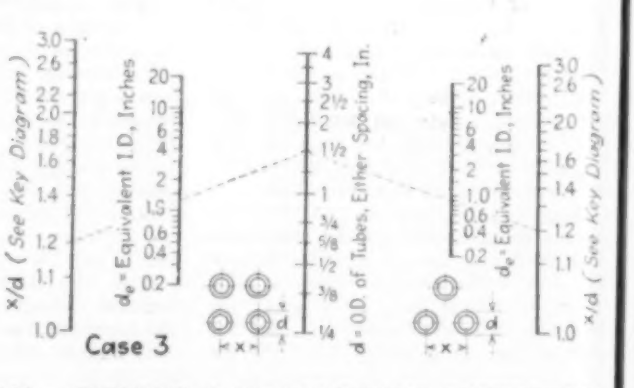


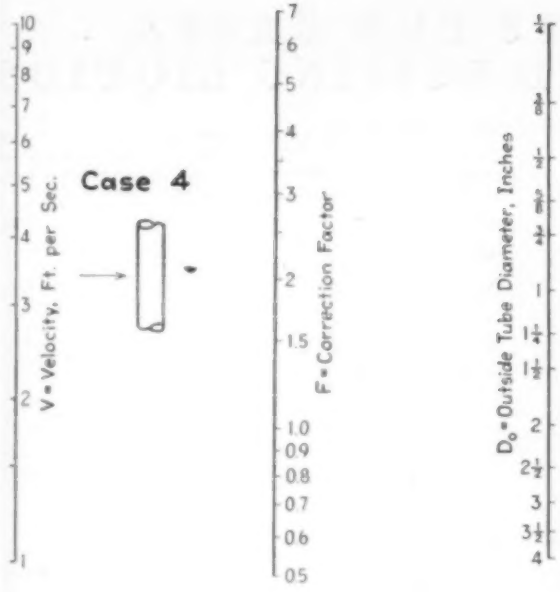
Case 3—Liquids Heated or Cooled Outside Tube Bundles, Direction of Flow Parallel to Tubes

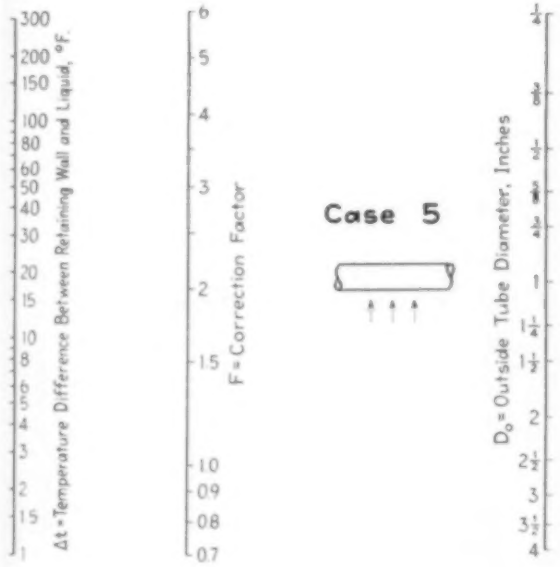
Film coefficients for liquids flowing outside tube bundles and in a direction parallel to the tubes can be determined from Cases 1 or 2 for liquids inside tubes, if an equivalent inside diameter is used in determining the correction factor. An equivalent diameter can be calculated by the following equation:

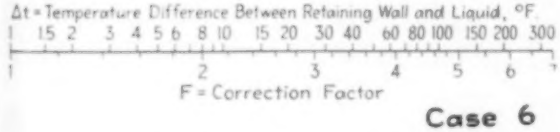
$$d_e = 4 \times \frac{A}{P},$$

in which d_e is the equivalent I.D., inches, A is the cross-sectional area between tubes in square inches, and P the sum of the tube perimeter segments forming the cross-section boundary, inches. For tubes based on equilateral triangles, or on squares, d_e can be read directly from the nomograph at the right.






Case 5
Δt = Temperature Difference Between Retaining Wall and Liquid, °F.
F = Correction Factor
D_o = Outside Tube Diameter, Inches



Case 4—Base Factors for Liquids Heated or Cooled Outside Single Tubes, Direction of Flow Normal to Tube

	Average Temperature of the Film					
	0° F.	50° F.	100° F.	150° F.	200° F.	250° F.
Acetic acid (100%)	.....	.....	142	136	131	126
Acetic acid (50%)	.....	214	260	292	310	321
Acetone	165	174	184	186	187	189
Ammonia	486	548	616	685	758	827
Amyl acetate	114	106	97.9	91.0	84.5	78.5
Amyl alcohol (iso)	54.6	73.0	94.9	118	140	165
Aniline	.....	97.0	116	139	164	194
Benzene	.....	124	140	152	163	174
Brine ($Ca Cl_2$) (25%)	264	335	419	508	617	734
Buyti alcohol (n)	85.5	100	112	136	167	208
Carbon disulphide	164	166	169	171	173	175
Carbon tetrachloride	.....	105	114	116	117	118
Chlorobenzene	118	112	108	106	103	101
Ethyl acetate	164	145	137	129	119	111
Ethyl alcohol (100%)	108	127	146	165	183	199
Ethyl alcohol (40%)	180	190	277	355	429	508
Ethyl bromide	151	137	142	144	146	147
Ethylene glycol (50%)	147	209	283	362	447	545
Ethyl ether	146	154	161	169	176	182
Glycerol (50%)	147	192	249	331	421	.....
Heptane	186	133	139	143	147	151
Hexane	198	134	141	147	151	155
Methyl alcohol (100%)	147	170	187	198	208	219
Methyl alcohol (90%)	159	186	200	226	258	251
Methyl alcohol (40%)	182	201	264	317	389	397
Octane (n)	117	124	129	136	140	146
Pentane (n)	130	144	148	151	158	154
Propyl alcohol (iso)	82.5	91.0	118	143	163	180
Sulphur dioxide	230	225	223	221	221	218
Sulphuric acid (60%)	.....	110	137	150	164	176
Toluene	128	135	142	148	152	155
Water	.....	382	497	525	645	700

Case 5—Base Factors for Liquids Heated Outside Single Horizontal Tubes, Natural Convection

	Average Temperature of the Film					
	0° F.	50° F.	100° F.	150° F.	200° F.	250° F.
Acetic acid (100%)	.....	.....	19.8	18.8	17.8	17.2
Acetone	.....	27.1	28.0	28.2	28.5	28.8
Ammonia	85.5	96.3	108	120	132	144
Benzene	.....	18.4	20.3	21.9	23.5	25.0
Carbon disulphide	23.9	24.1	24.6	24.8	25.1	25.3
Carbon tetrachloride	.....	15.7	16.6	16.5	16.5	16.9
Chlorobenzene	16.4	15.5	14.8	14.0	13.4	13.0
Ethyl acetate	23.5	21.7	20.1	18.5	17.1	15.6
Ethyl alcohol (100%)	15.6	18.1	20.6	23.1	25.3	27.4
Ethyl alcohol (40%)	17.9	26.6	36.5	47.2	57.8	.....
Ethyl bromide	20.1	20.7	21.1	21.5	21.7	21.9
Ethyl ether	22.3	23.9	24.8	25.6	26.4	26.9
Ethyl iodide	15.9	17.9	19.8	21.4	23.0	23.6
Heptane	19.4	20.0	20.4	21.0	21.6	21.9
Hexane	18.7	19.9	21.0	21.8	22.5	22.9
Methyl alcohol (100%)	22.5	25.2	27.1	28.7	29.8	30.9
Methyl alcohol (90%)	21.6	25.9	29.1	31.8	34.1	36.4
Octane (n)	17.0	18.1	18.5	19.2	20.0	20.6
Pentane (n)	21.9	22.3	22.8	23.3	24.0	24.4
Sulphur dioxide	37.9	37.2	36.5	36.0	35.6	35.2
Sulphuric acid (98%)	.....	11.9	15.6	19.5	23.1	.....
Sulphuric acid (60%)	.....	16.0	20.1	23.5	26.1	27.7
Toluene	43.0	45.5	47.9	49.8	51.2	51.7
Water	.....	11.9	15.5	17.8	19.5	21.1

Case 6—Base Factors for Liquids Heated Inside or Outside Vertical Tubes or on Vertical Plates, Low Velocities or Natural Convection Only

	Average Temperature of the Film					
	0° F.	50° F.	100° F.	150° F.	200° F.	250° F
Acetic acid (100%)	.....	.....	15.6	15.5	15.5	15.5
Acetone	21.0	22.6	24.1	24.8	25.3	25.8
Ammonia	75.0	88.5	103	118	130	155
Benzene	.....	14.4	16.4	18.2	20.0	21.7
Carbon disulphide	19.7	20.3	21.0	21.6	22.2	22.8
Carbon tetrachloride	11.4	12.7	13.8	14.2	14.4	14.8
Chlorobenzene	12.0	12.0	12.0	11.8	11.8	11.7
Ethyl acetate	18.6	18.1	17.4	16.6	15.9	15.0
Ethyl alcohol (100%)	10.8	13.2	15.9	18.6	21.2	23.9
Ethyl alcohol (40%)	10.2	17.4	26.2	35.1	45.4	.....
Ethyl bromide	17.1	18.0	18.8	19.4	19.8	20.2
Ethyl ether	19.4	21.0	22.3	23.4	24.1	24.6
Ethyl iodide	12.6	15.4	17.7	19.8	21.8	24.0
Heptane	14.8	15.6	16.6	17.2	18.5	19.6
Hexane	15.6	16.7	17.8	18.9	19.4	19.9
Methyl alcohol (100%)	16.7	19.5	21.9	23.9	25.9	27.4
Methyl (alcohol (90%)	15.1	19.4	22.6	25.4	27.8	30.2
Octane (n)	12.7	13.9	14.8	15.8	16.7	17.7
Pentane (n)	18.3	19.3	20.1	20.7	21.1	21.5
Sulphur dioxide	33.6	33.6	33.6	33.6	33.6	33.6
Sulphuric acid (98%)	.....	8.50	11.2	13.8	16.4	19.0
Sulphuric Acid (60%)	.....	12.2	16.1	19.2	21.1	23.1
Toluene	27.1	30.6	31.9	34.2	36.8	39.0
Water	.....	6.88	9.43	11.2	12.5	14.2

Case 7—Liquids Heated or Cooled Outside Tube Bundles, Direction of Flow Normal to Tubes

Use data for Case 4 and multiply answer by 1.2 for tubes in line or by 1.3 for staggered tubes. For determining correction factor use velocity at narrowest section between tubes. For baffled heat exchangers, where a small part of the flow is parallel to tubes, use Case 4 data directly, but evaluate correction factor at velocity between tubes at widest part of shell, calculated as

$$144\,Q \times (d_s - nd)\,l.$$

Q is rate of flow (cu. ft. per sec.); d_s is inside shell dia. (in.); d is outside tube bundle dia. (in.); n is no. of tubes across wide part of shell; and l is distance between baffles.

Case 8—Liquids Heated or Cooled in Annular Spaces, Turbulent Flow

Use data for Case 1 (heating), or Case 2 (cooling), but substitute an equivalent diameter equal to $(d_1^2 - d_2^2) \div d_1$ in determining correction factor on nomograph. d_1 is inside diameter of outer pipe and d_2 is outside diameter of inner pipe.

Case 9—Liquids Heated or Cooled Inside Coils, Turbulent Flow

Use data for Case 1 (heating), or Case 2 (cooling), and multiply answer by 1.2.

Case 10—Liquids Heated or Cooled Outside Coils, Natural or Forced Convection

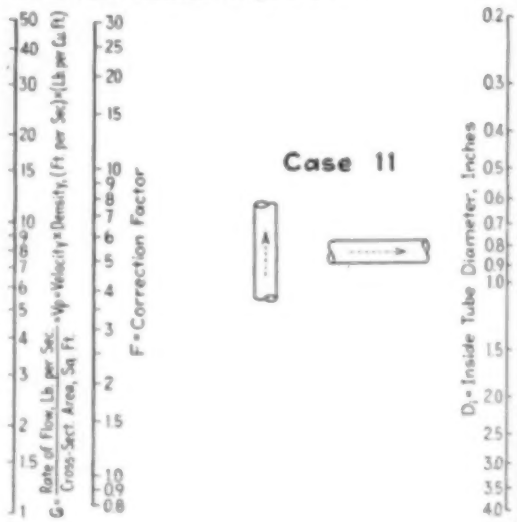
Use data for Case 4 (forced convection), or Case 5 (natural convection).

FILM COEFFICIENTS FOR GASES, CONDENSING VAPORS AND BOILING LIQUIDS

Film coefficients for gases, condensing vapors and boiling liquids are obtained in the same way as was explained for liquids on page 102. Several special cases including an equation for scale coefficients are given here.

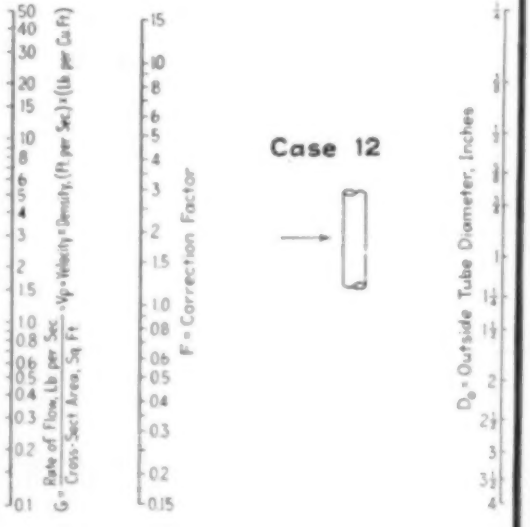
Case 11—Base Factors for Gases Heated or Cooled Inside Horizontal or Vertical Tubes, Turbulent Flow

	Average Temperature of the Gas						
	−100° F.	0° F.	100° F.	200° F.	300° F.	400° F.	500° F.
Acetone	.....	.....	3.98	4.58	5.26	6.33	7.86
Acetylene	4.47	4.90	5.32	5.75	6.15	6.55	.....
Air	3.52	3.76	3.92	4.09	4.19	4.37	4.59
Ammonia	4.87	5.68	6.25	6.69	7.06	7.56	7.94
Benzene	.....	.....	3.61	4.33	5.20	6.10	7.00
Butane	.....	4.61	5.48	5.98	6.49	6.74	7.05
Carbon dioxide	3.57	3.59	3.14	3.33	3.49	3.64	3.83
Carbon monoxide	3.53	3.77	3.97	4.17	4.35	4.49	4.66
Chlorine	1.59	1.66	1.73	1.78	1.82	1.88	1.92
Chloroform	.....	.....	1.90	2.07	2.26	2.45	2.64
Ethane	4.06	4.83	5.55	6.28	7.00	7.72	8.45
Ethyl acetate	.....	.....	3.81	4.49	5.14	5.75	6.32
Ethyl alcohol	.....	.....	5.22	5.44	5.64	5.86	6.06
Ethyl chloride	.....	3.08	3.50	3.75	3.89	4.05	4.18
Ethylene	5.89	4.36	5.19	5.75	6.35	6.90	7.46
Ethyl ether	.....	4.71	5.30	5.93	6.65	7.47	8.79
Helium	20.6	21.2	21.9	22.6	23.3	23.9	24.6
Hydrogen	45.1	47.7	49.6	51.6	53.6	55.6	57.5
Hydrogen sulphide	2.68	2.90	3.18	3.37	3.60	3.79	3.98
Methane	6.68	7.49	8.08	8.47	8.79	9.11	9.36
Methyl chloride	1.88	2.36	2.85	3.31	3.74	4.16	4.56
Nitric oxide	3.42	3.62	3.77	3.89	3.99	4.07	4.15
Nitrogen	3.52	3.68	4.11	4.24	4.33	4.41	4.49
Nitrous oxide	2.67	2.94	3.00	3.06	3.13	3.18	3.24
Oxygen	3.38	3.57	3.71	3.82	3.93	4.01	4.09
Pentane (iso)	.....	4.78	5.37	6.13	7.00	8.08	.....
Steam	.....	.....	5.82	6.00	6.18	6.41	6.64
Sulphur dioxide	.....	1.93	2.00	2.10	2.20	2.28	2.36


Case 11
A
G = Rate of Flow, Lb per Sec. ÷ Cross-Sect Area, Sq Ft
Vp = Velocity × Density, (Ft per Sec) × (Lb per Cu Ft)
F = Correction Factor
D1 = Inside Tube Diameter, Inches

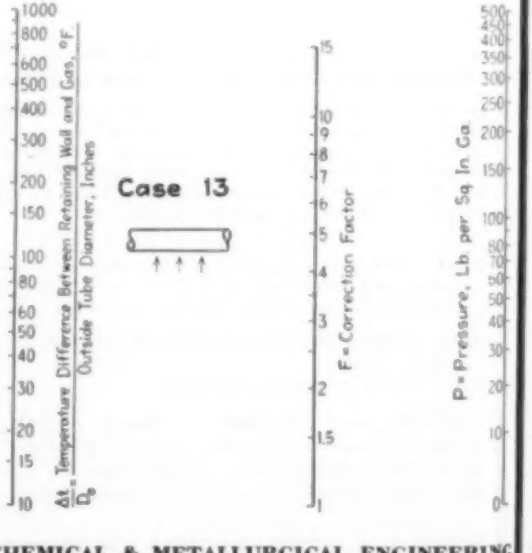
Case 12—Base Factors for Gases Heated or Cooled Outside Single Tubes, Direction of Flow Normal to Tube, Turbulent Flow

	Average Temperature of the Film						
	−100° F.	0° F.	100° F.	200° F.	300° F.	400° F.	500° F.
Acetone	.....	.....	6.69	8.09	9.63	11.4	13.1
Acetylene	7.16	8.54	9.92	11.2	12.4	13.6	.....
Air	6.97	7.71	8.38	8.96	9.46	9.88	10.3
Ammonia	8.34	10.4	12.1	13.4	14.6	15.7	16.8
Benzene	.....	.....	6.16	7.70	9.55	11.5	.....
Butane	.....	8.05	9.47	10.0	12.4	13.9	15.4
Carbon dioxide	4.83	5.57	6.32	6.95	7.59	8.15	8.73
Carbon monoxide	6.91	7.68	8.42	9.10	9.79	10.4	11.0
Chlorine	2.46	3.12	3.29	3.63	3.98	4.06	4.27
Chloroform	.....	.....	3.46	3.94	4.46	5.02	5.55
Ethane	6.82	8.46	10.2	12.3	14.4	.....	.....
Ethyl acetate	.....	.....	6.42	7.85	9.38	10.9	12.6
Ethyl alcohol	.....	.....	9.10	9.75	10.5	11.1	11.7
Ethyl chloride	.....	4.80	5.59	6.30	6.93	7.16	8.27
Ethylene	6.40	8.02	9.54	11.0	12.5	13.9	15.4
Ethyl ether	.....	7.78	8.95	10.3	12.0	14.1	16.1
Helium	41.8	45.2	48.1	50.9	53.5	56.8	59.6
Hydrogen	73.5	82.4	88.8	94.8	97.7	101	105
Hydrogen sulphide	4.94	5.55	6.10	6.59	7.08	7.28	7.78
Methane	7.61	8.32	8.95	9.57	10.1	10.7	11.3
Methyl chloride	3.68	4.09	5.25	6.30	7.40	8.37	.....
Nitric oxide	6.64	7.36	8.00	8.56	9.04	9.44	9.84
Nitrogen	7.33	8.06	8.67	9.18	9.53	9.87	10.2
Nitrous oxide	5.49	5.72	5.90	6.01	6.09	6.49	6.90
Oxygen	6.83	7.54	8.12	8.60	9.00	9.50	9.80
Pentane (iso)	.....	7.40	8.91	10.6	12.5	14.4	.....
Steam	.....	.....	9.97	11.1	12.1	13.1	14.0
Sulphur dioxide	.....	3.42	3.83	4.21	4.52	4.79	5.10


Case 12
G = Rate of Flow, Lb per Sec. ÷ Cross-Sect Area, Sq Ft
Vp = Velocity × Density, (Ft per Sec) × (Lb per Cu Ft)
F = Correction Factor
D0 = Outside Tube Diameter, Inches

Case 13—Base Factors for Gases Heated Outside Single Horizontal Tubes, Natural Convection

	Average Temperature of the Film						
	−100° F.	0° F.	100° F.	200° F.	300° F.	400° F.	500° F.
Acetone	.....	.....	0.94	1.06	1.19	1.33	1.45
Acetylene	0.83	0.90	0.96	1.02	1.07	1.13	1.18
Air	0.91	0.89	0.88	0.87	0.85	0.84	0.83
Ammonia	0.82	0.88	0.94	0.99	1.04	1.08	1.13
Benzene	.....	.....	1.00	1.17	1.36	1.58	1.80
Butane	.....	1.25	1.36	1.47	1.58	1.68	1.78
Carbon dioxide	0.71	0.76	0.80	0.82	0.84	0.86	0.87
Carbon monoxide	0.86	0.86	0.86	0.85	0.84	0.83	0.82
Chlorine	.....	0.86	0.85	0.85	0.85	0.84	0.83
Chloroform	.....	.....	0.72	0.77	0.82	0.86	0.91
Ethane	0.85	0.95	1.06	1.16	1.26	1.36	1.46
Ethyl acetate	.....	.....	1.12	1.29	1.45	1.60	1.76
Ethyl alcohol	.....	.....	1.17	1.16	1.15	1.13	1.10
Ethyl chloride	.....	.....	0.84	0.89	0.94	0.98	1.03
Ethylene	0.79	0.88	0.95	1.04	1.11	1.19	1.26
Ethyl ether	.....	.....	1.42	1.57	1.72	1.88	2.03
Helium	2.02	1.94	1.88	1.84	1.80	.....	.....
Hydrogen	2.44	2.30	2.34	2.30	2.26	2.21	2.16
Hydrogen sulphide	.....	0.66	0.67	0.68	0.68	.....	.....
Methane	1.04	1.15	1.21	1.27	1.33	1.39	1.44
Methyl chloride	.....	0.61	0.71	0.79	0.87	0.95	1.03
Nitric oxide	0.86	0.86	0.85	0.84	0.82	0.81	0.79
Nitrogen	0.92	0.91	0.89	0.87	0.85	0.84	0.81
Nitrous oxide	0.86	0.79	0.75	0.71	0.68	0.65	.....
Oxygen	0.92	0.91	0.90	0.89	0.87	0.86	0.84
Pentane (iso)	.....	1.26	1.40	1.56	1.74	1.92	2.14
Steam	.....	.....	0.80	0.81	0.82	0.85	0.86
Sulphur dioxide	.....	.....	0.59	0.60	0.61	0.61	0.61

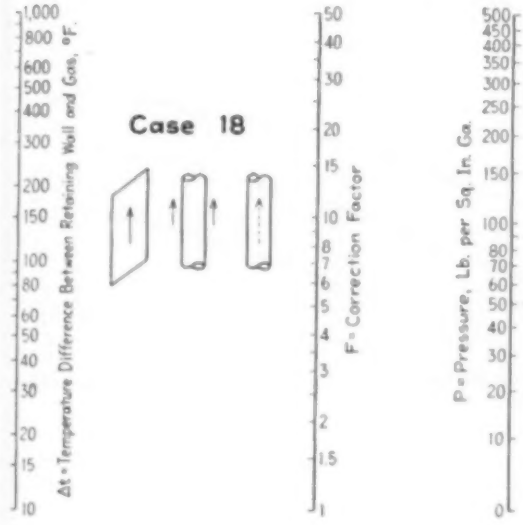

Case 13
Δt = Temperature Difference Between Retaining Wall and Gas, °F.
D0 = Outside Tube Diameter, Inches
F = Correction Factor
P = Pressure, Lb per Sq In Ga

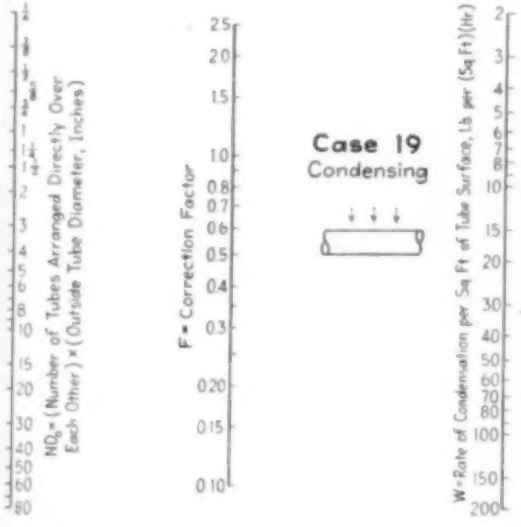
Case 14—Gases Heated or Cooled Outside Tube Bundles, Direction of Flow Parallel to Tubes

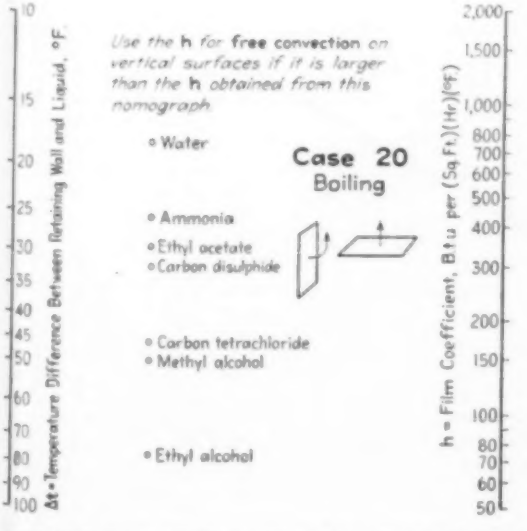
Use Case 11 data but substitute an equivalent diameter in determining correction factor as in Case 3.

Case 15—Cases Heated or Cooled Outside Tube Bundles, Direction of Flow Normal to Tubes

See Case 7. Instead of using data for Case 4 as directed in Case 7, use data from Case 12 and correct in the same way.






Use the h for free convection on vertical surfaces if it is larger than the h obtained from this nomograph
Case 20
Boiling
Water
Ammonia
Ethyl acetate
Carbon disulphide
Carbon tetrachloride
Methyl alcohol
Ethyl alcohol
Δt = Temperature Difference Between Retaining Wall and Liquid, °F.
h = Film Coefficient, B.t.u. per (Sq Ft.)(Hr.)(°F.)

Case 16—Gases Heated or Cooled in Annular Spaces, Turbulent Flow

Use data for Case 11 but substitute an equivalent diameter as described in Case 8.

Case 17—Gases Heated or Cooled Outside Coils, Natural or Forced Convection

Coefficients for these cases are approximately the same as for Cases 12 or 13, and these data should be used.

Case 18—Base Factors for Gases Heated Inside or Outside Vertical Tubes or on Vertical Plates, Natural Convection

	Average Temperature of the Film						
	—100° F.	0° F.	100° F.	200° F.	300° F.	400° F.	500° F.
Acetone	.....	.....	0.65	0.69	0.73	0.78	*0.85*
Acetylene	0.56	0.55	0.54	0.53	*0.53*	*0.53*	*0.53*
Air	0.53	0.49	0.46	0.43	0.41	0.39	*0.38*
Ammonia	0.50	0.50	0.50	0.49	*0.49*	*0.48*	*0.48*
Benzene	.....	.....	0.72	0.79	0.88	0.97	*1.06*
Butane	.....	0.83	0.93	0.94	*0.96*	*0.97*	*0.98*
Carbon dioxide	0.49	0.48	0.47	0.46	0.45	0.44	0.43
Carbon monoxide	0.51	0.48	0.45	0.42	*0.40*	*0.38*	*0.36*
Chlorine	.....	0.38	0.36	0.34	*0.33*	*0.31*	*0.30*
Chloroform	.....	.....	0.53	0.53	0.54	0.55	*0.56*
Ethane	0.57	0.59	0.61	0.63	*0.65*	*0.67*	*0.69*
Ethyl acetate	.....	.....	0.83	0.89	0.95	1.02	*1.06*
Ethyl alcohol	.....	.....	0.76	0.71	*0.67*	*0.63*	*0.58*
Ethyl chloride	.....	.....	0.56	0.55	0.54	*0.54*	*0.53*
Ethylene	*0.53*	0.54	0.55	0.56	*0.58*	*0.59*	*0.60*
Ethyl ether	.....	.....	1.03	1.05	1.11	*1.17*	*1.24*
Helium	0.83	0.74	0.69	*0.65*	*0.62*	.....	.....
Hydrogen	1.04	0.95	0.88	0.82	*0.77*	*0.73*	*0.68*
Hydrogen sulphide	.....	0.41	0.39	0.37	*0.35*	.....	.....
Methane	0.46	0.45	0.44	*0.43*	*0.42*	*0.41*	*0.40*
Methyl chloride	.....	0.41	0.45	0.48	0.51	*0.54*	*0.56*
Nitric oxide	0.52	0.48	0.45	0.42	*0.40*	*0.37*	*0.35*
Nitrogen	0.54	0.49	0.46	0.43	*0.40*	*0.38*	*0.36*
Nitrous oxide	0.55	0.49	0.44	*0.40*	*0.37*	*0.34*	.....
Oxygen	0.54	0.50	0.47	0.44	*0.41*	*0.39*	*0.37*
Pentane (iso)	.....	0.99	1.01	1.05	*1.12*	*1.20*	*1.30*
Steam	.....	.....	0.44	0.42	0.41	0.40	0.39
Sulphur dioxide	.....	.....	0.38	0.36	0.35	0.34	0.33

Case 19— Base Factors for Condensation of Pure Saturated Vapors on Horizontal Tubes

	—Temperature of Condensate Film (Assume Equal to Tube Wall)—					
	50° F.	100° F.	150° F.	200° F.	250° F.	300° F.
Acetic acid	.....	511	495	470	424	373
Acetone	772	789	805	805	795	780
Ammonia	2,768	3,145	3,459	3,711	*3,875*	*3,965*
Aniline	*575*	405	544	685	830	977
Benzene	554	609	658	706	755	798
Carbon disulphide	934	933	933	934	905	868
Carbon tetrachloride	551	580	509	*481*	.....	.....
Chloroform	735	791	847	*895*	*950*	*997*
Ethyl acetate	*709*	772	835	889	936	990
Ethyl alcohol	*495*	556	618	678	745	807
Ethyl ether	620	646	665	678	691	705
Heptane	*488*	537	580	607	628	645
Hexane	*595*	552	576	592	608	614
Methyl alcohol	695	772	850	920	972	103
Octane	*488*	513	538	554	575	585
Propyl alcohol (iso)	*564*	400	488	548	*596*	*638*
Steam	900	1,200	1,485	1,764	2,028	2,292
Sulphur dioxide	2,565	2,440	2,269	2,025	*1,850*	*1,580*

Case 20—Liquids Boiling on Horizontal or Vertical Plates

Use nomograph at left. For water boiling at pressures other than atmospheric multiply by the following correction factor:

Abs. press. (atm.)	0.2	0.4	0.6	0.8	1.0	2.0	4.0	6.0	8.0	10.0	15.0
Corr. fact.	0.62	0.78	0.88	0.94	1.00	1.16	1.32	1.40	1.46	1.51	1.60

Case 21—Gases Heated or Cooled Inside Coils, Turbulent Flow

Use the following equation: $h_{coils} = (1 + 3.54\ (d/d_c)) \times h_{tubes}$, where d is the inside diameter of the pipe or tube in inches, d_c is the diameter of the coil in inches, and h_{tubes} is the straight tube coefficient, from Case 11.

Case 22—Air Heated on Horizontal Plates, Natural Convection

For large plates (3 sq. ft. or more) get coefficient from Case 18 and multiply by 1.27 for horizontal plates facing downward, or by 0.67 for plates facing upward. If radiation is an important factor, a combined coefficient can be obtained by adding the product of the emissivity of the surface and the radiation coefficient, which is defined as: $h_1 = 0.173 \times 10^{-8}\ (T_1^4 - T_2^4) \div (T_1 - T_2)$, where T_1 is the temperature of the emitting surface, deg. F. abs., and T_2 is the temperature of the absorbing surface, deg. F. abs.

Case 23—Liquids Boiling Inside Tubes

When liquid moves by natural convection only, use coefficient from Case 20 and multiply by 1.25. If liquid moves at high velocity use coefficient from Case 1 since conditions then are as if there were no evaporation.

Case 24—Scale Coefficients

When scale thickness is known, rough values of coefficient are obtained by dividing the scale thermal conductivity by its thickness. A mean value of 1.0 B.t.u./(ft.) (hr.) (deg. F.) may be taken for scale conductivity although it will vary with the kind and porosity of the scale. The following coefficients may be used for the kinds of convection indicated: For condensing steam, 3,000; for condensing petroleum vapors, 500; for heating muddy water, 600; and heating residual petroleum stocks, 200 B.t.u./(sq. ft.) (hr.) (deg. F.).

(Continued from page 101)

A more accurate value of t_w can now be determined by Eq. (15):

$$t_w = \frac{32 \times 150 + 70 \times 80}{32 + 70} = 102 \text{ deg. F.}$$

Redetermining h_2 for this value of t_w, $h_2 = 46.0$ B.t.u./(sq.ft.)(hr.)(deg. F.) (at $t_f = (102 + 80)/2 = 91$ deg. F.), $F = 1.92$ ($\Delta t = 102 - 80 = 22$ deg. F.), and, finally,

$h_2 = 46.0 \times 1.92 =$
88 B.t.u./(sq. ft.) (hr.) (deg. F.).

The overall coefficient U can be calculated by Eq. (13): Since the pipe wall is 0.140 in. thick and the thermal conductivity of steel is about 26 B.t.u./(ft.)(hr.)(deg. F.),

$$\frac{1}{U} = \frac{1.66}{32 \times 1.38} + \frac{0.140}{12 \times 26} + \frac{1}{88},$$

or

$U = 20$ B.t.u./(sq. ft.) (hr.) (deg. F.)
(clean pipe.)

Allowance should be made for the presence of scale on the outside surface of the pipe. Assuming a value of $h_s = 120$ B.t.u./(sq.ft.)(hr.)(deg. F.), by Eq. (16),

$$\frac{1}{U_s} = \frac{1}{20} + \frac{1}{120},$$

or

$U_s = 17$ B.t.u./(sq. ft.) (hr.) (deg. F.)
(scaly pipe).

The mean temperature difference between the air and the water can be calculated by Eq. (17):

$$\Delta t_{l.m.} = \frac{(210 - 80) - (90 - 80)}{2.3 \log_{10}\left(\frac{210 - 80}{90 - 80}\right)} = 47 \text{ deg. F.}$$

The outside pipe surface required can now be calculated by Eq. (11):

$$13{,}000 = 17 \times A \times 47,$$

or

$$A = 16.3 \text{ sq. ft.}$$

Since 2.301 lin. ft. of 1¼-in. pipe have 1 sq.ft. of outside surface, the total length of pipe needed in the coil is $2.301 \times 16.3 = 37.5$ ft.

DETERMINATION OF FILM COEFFICIENTS

The film coefficients for most cases of heat transfer by convection must be determined by experiment because the motion of the fluid and the temperature distribution are too complicated to permit them to be predicted from purely theoretical considerations. Moreover, the amount of experimental work required to determine them is very great because for each case they depend upon many factors. Fortunately, the experimental work required can be reduced, and the results obtained with a few fluids can be used to predict film coefficients for other fluids by means of dimensional analysis.

As an example of the usefulness of dimensional analysis in reducing the amount of experimental work required and in interpreting the results obtained, consider the case of fluids flowing normal to single tubes which are at some temperature higher than that of the fluid. For any given tube diameter, tube temperature, kind of fluid, and fluid temperature, the film coefficient h corresponding to any velocity V can be determined by experiment, and the resulting values of h can be plotted against V. Some of the results obtained by Hughes (*Phil. Mag.*, vol. 31, p. 118, 1916.) for air at room temperature flowing normal to several different diameter cylinders at 212 deg. F., and some of the results obtained by Schindler (Schindler, L. W., Thesis in Mechanical Engineering, Iowa State College, Ames, Iowa, 1942.) for water at 87 deg. F. flowing normal to a ¾-in. tube at 125 deg. F. are plotted this way in Fig. 2. Since other results would have been obtained had the temperatures of the fluids or of the tubes been changed, it is evident that the separate curves will be obtained for each combination of tube diameter, tube temperature, kind of fluid, and fluid temperature plotted. On the other hand, if such results are plotted on the coordinates suggested by dimensional analysis, all the data can be made to fall upon a single curve.

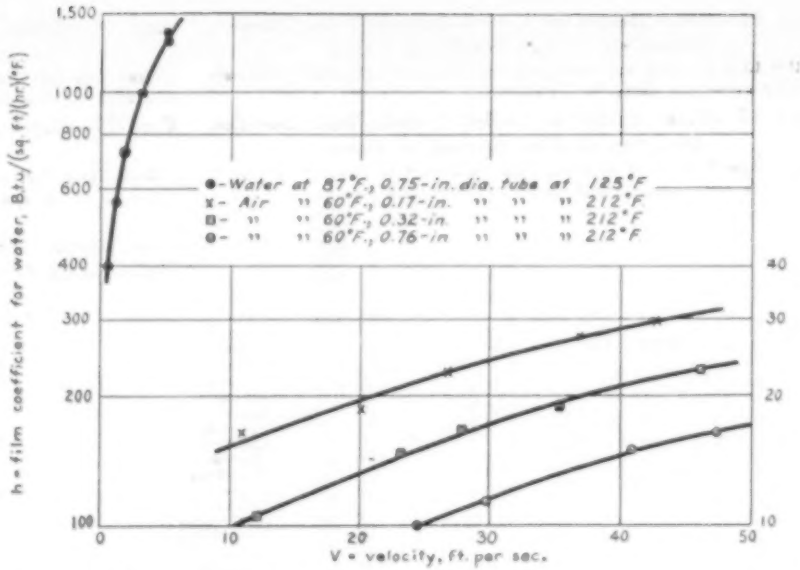

h = film coefficient for water, B.t.u./(sq ft)(hr)(°F)
h = film coefficient for air, B.t.u./(sq ft)(hr)(°F)
V = velocity, ft. per sec.
● - Water at 87°F., 0.75-in. dia. tube at 125°F
x - Air " 60°F., 0.17-in. " " " 212°F
□ - " " 60°F., 0.32-in. " " " 212°F
○ - " " 60°F., 0.76-in. " " " 212°F

Fig. 2—Film coefficients for air and water flowing normal to single tubes

The film coefficient h depends upon the tube diameter D, the velocity V, and the viscosity μ, thermal conductivity k, density ρ, and specific heat c_p of the fluid; that is

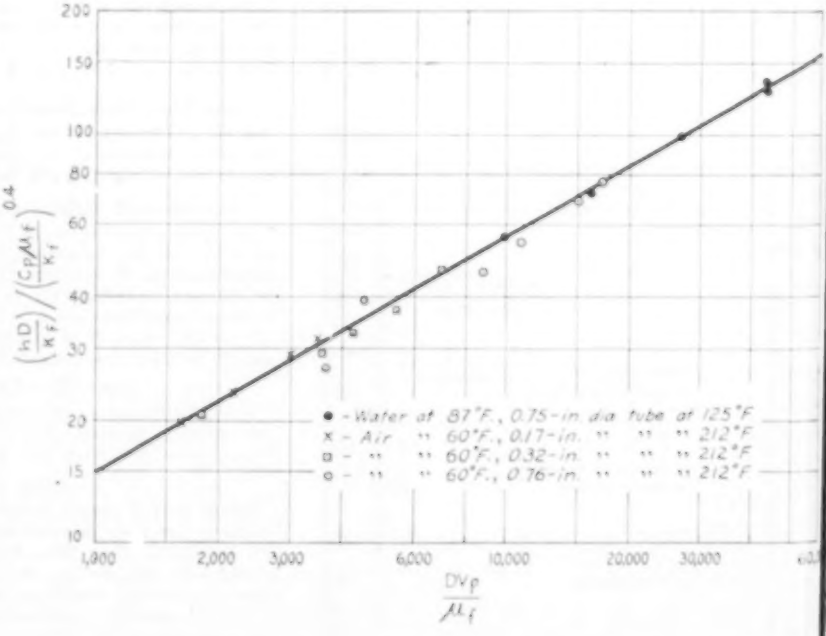
$$h = \phi(D, V, \mu, k, \rho, c_p).$$

This unknown function can be expressed as an exponential series

$$h = \alpha_1 D^{a_1} V^{b_1} \mu^{c_1} k^{d_1} \rho^{e_1} c_p^{f_1} + \alpha_2 D^{a_2} V^{b_2} \mu^{c_2} k^{d_2} \rho^{e_2} c_p^{f_2} + \ldots \quad (18)$$

in which each term is of the form $\alpha D^a V^b \mu^c k^d \rho^e c_p^f$, and α, a, b, c, d, e, and f are dimensionless constants. Each of the terms in the right-hand member of this equation must have the same net dimen-

Fig. 3—Data of Fig. 2 plotted as suggested by dimensional analysis


$\left(\frac{hD}{k_f}\right) / \left(\frac{c_p \mu_f}{k_f}\right)^{0.4}$
$\frac{DV\rho}{\mu_f}$
● - Water at 87°F., 0.75-in. dia. tube at 125°F
x - Air " 60°F., 0.17-in. " " " 212°F
□ - " " 60°F., 0.32-in. " " " 212°F
○ - " " 60°F., 0.76-in. " " " 212°F

sions as the terms of the left-hand member.

In terms of the five fundamental dimensions, mass m, length l, time θ, temperature t, and heat H, the dimensions of the film coefficient h are $H/l^2\theta t$, of the diameter D are l, of the velocity V are l/θ, of the viscosity μ are $m/l\,\theta$, of the density ρ are m/l^3, and of the specific heat c_p are $H/m\,t$. Hence, equating the dimensions of the general term $aD^aV^b\mu^c k^d \rho^e c_p{}^f$ to the dimensions of h,

$$(l)^a\left(\frac{l}{\theta}\right)^b\left(\frac{m}{l\theta}\right)^c\left(\frac{H}{l\theta t}\right)^d\left(\frac{m}{l^3}\right)^e\left(\frac{H}{mt}\right)^f=\left(\frac{H}{l^2\theta t}\right)$$

or

$$m^{c+e-f}l^{a+b-c-d-3e+2}\theta^{-b-c-d+1}t^{-d-f+1}H^{d+f-1}=1.$$

SOLUTION OF DIMENSIONLESS EQUATION

This equation will be satisfied if each of the exponents is equal to zero:

$$\begin{aligned} c+e-f&=0,\\ a+b-c-d-3e+2&=0,\\ -b-c-d+1&=0,\\ -d-f+1&=0,\\ d+f-1&=0. \end{aligned}$$

Solving these five simultaneous equations for a, b, c, and d in terms of e and f,

$$\begin{aligned} a&=-1+e\\ b&=e\\ c&=-e+f\\ d&=1-f \end{aligned}$$

Hence, each term of the series must be of the form

$$aD^aV^b\mu^c k^d\rho^e c_p{}^f=aD^{-1+e}V^e\mu^{-e+f}k^{1-f}\rho^e c_p{}^f$$

$$=\alpha\left(\frac{k}{D}\right)\left(\frac{DV\rho}{\mu}\right)^e\left(\frac{c_p\mu}{k}\right)^f,$$

and Eq. (18) can be written

$$=\alpha_1\left(\frac{k}{D}\right)\left(\frac{DV\rho}{\mu}\right)^{e_1}\left(\frac{c_p\mu}{k}\right)^{f_1}+\alpha_2\left(\frac{k}{D}\right)\left(\frac{DV\rho}{\mu}\right)^{e_2}\left(\frac{c_p\mu}{k}\right)^{f_2}+\cdots.$$

or

$$\frac{hD}{k}=\alpha_1\left(\frac{DV\rho}{\mu}\right)^{e_1}\left(\frac{c_p\mu}{k}\right)^{f_1}+\alpha_2\left(\frac{DV\rho}{\mu}\right)^{e_2}\left(\frac{c_p\mu}{k}\right)^{f_2}+\cdots.$$

or

$$\frac{hD}{k}=\phi\left(\frac{DV\rho}{\mu},\frac{c_p\mu}{k}\right).$$

Thus, dimensional analysis indicates that the dimensionless group of terms hD/k depends only upon the dimensionless groups $DV\rho/\mu$ and $c_p\mu/k$; therefore, if these three quantities are used as the coordinates, all the experimental data will fall upon a single surface.

A further simplification is possible because studies of the data for this type of convection have shown that the function $(DV\rho/\mu,\ c_p\mu/k)$ is of the form $(c_p\mu/k)^n\cdot\psi\ (DV\rho/\mu)$, where n is a constant. Thus, if $(hD/k)/(c_p\mu/k)^{0.4}$ is plotted against $(DV\rho/\mu)$, a single curve is obtained. The data shown in Fig. 2 are plotted in this way in Fig. 3. The viscosity, thermal conductivity, and specific heat are evaluated at the film temperature, and the density is evaluated at the temperature of the main body of the fluid.

The equation of the straight line shown in Fig. 3 can be readily written, and, if the properties of the fluid are known, this equation can be used to calculate values of the film coefficient h for any fluid flowing normal to any diameter tube.

In a similar manner, dimensional analysis has been used in studying the data for other types of convection, and equations made up of dimensionless groups of terms have been derived. The tables and nomographs presented on pages 102 to 105 have been prepared from such equations, which are available in all standard texts on heat transfer. [The particular equations used are presented for the cases cited in the author's book, "Applied Heat Transmission," Chap. IV, (McGraw-Hill Book Co., Inc., 1941).—Editor.]

FILM COEFFICIENTS

For the Condensation of Vapors

ROBERT F. BENENATI and DONALD F. OTHMER
Polytechnic Institute of Brooklyn, N. Y.

ON THE FOLLOWING page there appears a parallel-scale type nomograph for determining film coefficients of condensing vapors from their physical properties. This nomograph was constructed from the equation

$$h=77.5\sqrt[3]{\frac{k^2\rho^{4/3}L}{\mu^{1/6}D\,\Delta T}}$$

based on Nusselt's equation and derived by Othmer and Berman from physical properties of seventeen organic vapors studied experimentally. (*Ind. Eng. Chem.*, 35, 1943, p. 1068)

The equations fit all the physical data within their probable errors, which were believed greater in some cases than the probable errors in the experimental study. Because of the large number of vapors worked with, the equation may be regarded as general and may be used with reasonable probability of accuracy for vapors where experimental data are not known.

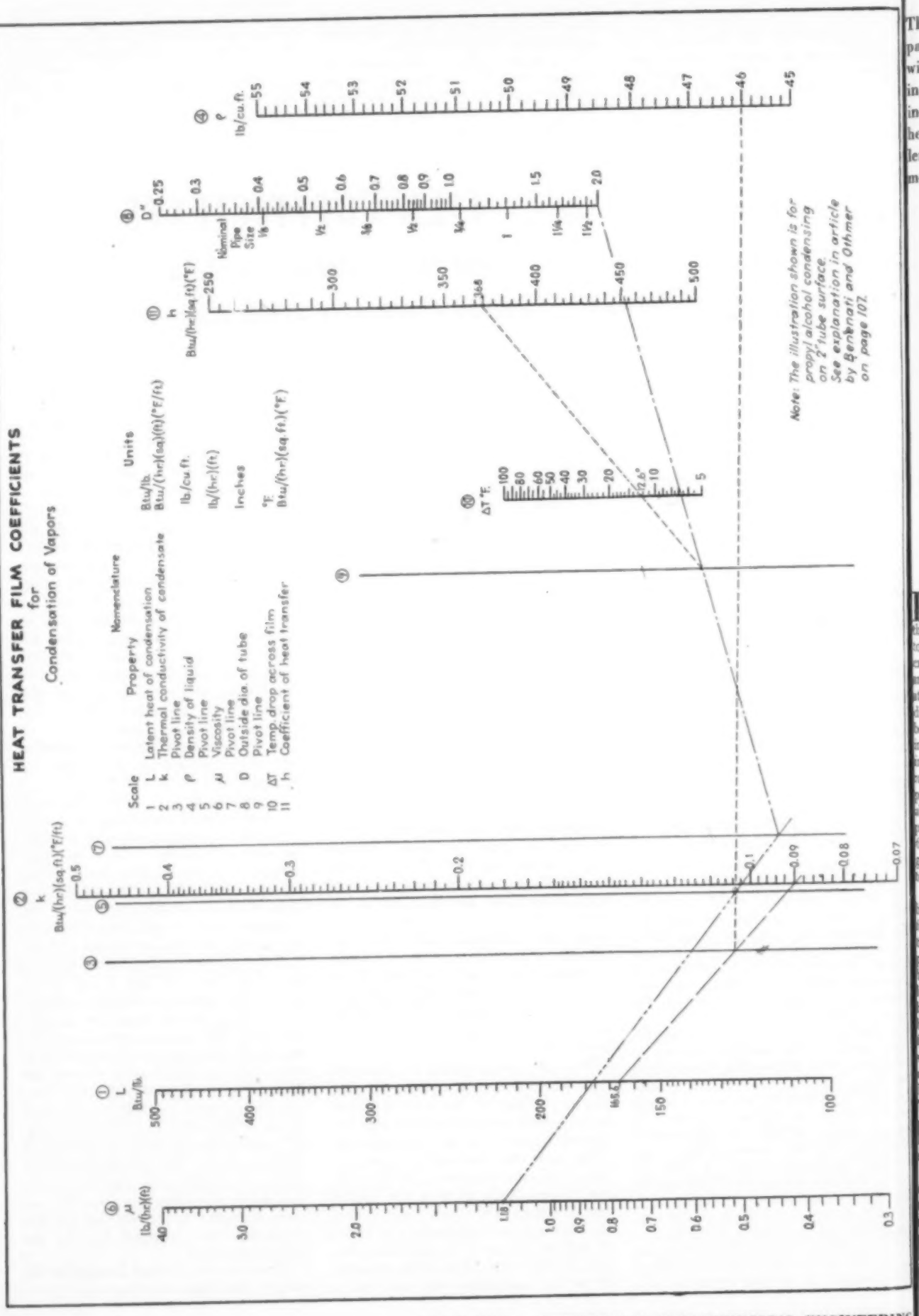
Nomenclature and units are presented on the nomogram for seven calibrated scales representing four physical properties of the particular material, the mean film temperature, the diameter of the condenser tubes and the temperature drop across the condensate film. For convenience in use, the diameter of the tube is expressed in actual inches and also in nominal iron pipe size. Finally, there is the scale of the coefficient, plus four uncalibrated lines to be used as reference or pivot lines.

The scales are numbered and also indicated by the symbol representing the property or function of the particular scale. In use, there are obtained first the four physical properties of the condensate film at the mean film temperature, namely the latent heat of condensation, L, in B.t.u./lb.; the thermal conductivity of the condensate, k, in B.t.u./(hr.)(sq.ft.)(deg. F./ft.); the density of the condensate, ρ, in lb./cu. ft.; and the viscosity of the condensate film, μ, in lb./(hr.)(ft.). The outside diameter, D, of the condensing tube and the assumed temperature drop, ΔT are known. It remains therefore to find the coefficient of heat transfer, h in B.t.u./(hr.)(sq. ft.)(deg. F.).

The use of the chart follows directly by placing the values on the scales in numerical order: #1, L, (latent heat) is joined with #2, k, (thermal conductivity) to give a point on reference scale #3, which point in turn is joined with the value of ρ, (density) on #4. The intersection of this line with reference line #5 is connected with the value of μ, (viscosity) on #6. This line, when extended, gives an intersection on the reference line, #7, which intersection is connected with (D) (diameter of the tube) on scale #8. This line crosses reference line #9 and this intersection is connected with a line through (ΔT) (temperature drop), on #10, to give a line which on extrapolation shows the desired value of h, (film coefficient) on scale #11.

An example is shown on the nomograph for propyl alcohol condensing on a tube surface of 2 in. diameter, at a film temperature drop of 12.6 deg. F. The vapor temperature is the normal atmospheric boiling point of propyl alcohol 176.3 deg. F.; the mean temperature is assumed to be the arithemetic mean for the determination of the physical properties, in this case 170 deg. F. L, k, ρ, and μ, are found from tables to be 165.6, 0.09, 46, and 1.176. These values, when applied on the scale in succession as above, give an intersection on reference scale #7, representing the combination of the functions of the physical properties. This is then worked through the values of tube diameter and temperature drop for the given problem to give a final answer of 368 B.t.u./(hr.) (sq. ft.) (deg. F.), whereas the calculated value using the equation above is 362, the difference representing a negligible percentage due to the inaccuracies of reading the scales. The experimental value for h is 390, and this also varied from the correlated line for the experimental work.

Thanks are due to Saul Berman for his help in calculations and checking.


HEAT TRANSFER FILM COEFFICIENTS
for
Condensation of Vapors
Nomenclature
Scale
Property
Units
1 L Latent heat of condensation Btu/lb.
2 k Thermal conductivity of condensate Btu/(hr)(sq)(ft)(°F/ft)
3 Pivot line
4 ρ Density of liquid lb/cu ft.
5 Pivot line
6 μ Viscosity lb/(hr)(ft)
7 Pivot line
8 D Outside dia of tube Inches
9 Pivot line
10 ΔT Temp. drop across film °F
11 h Coefficient of heat transfer Btu/(hr)(sq ft)(°F)
Note: The illustration shown is for propyl alcohol condensing on 2" tube surface.
See explanation in article by Berenati and Othmer on page 107.

The remainder of this special section consists of three parts all dealing from somewhat different standpoints with problems that arise in adding heat to, or removing it from, the raw materials and products of process industries. The first of these articles is concerned with heat and cold production and with the general problem of heat transfer, usually in cases where no special medium for the transfer of heat is introduced into the process. The second article discusses heat transfer media of special types, for use where non-media transfer is unsatisfactory. Finally, the third article treats primarily the equipment of heat transfer, including both those types in which heating or cooling is the main purpose, as well as many other types in which heat transfer plays an important but still secondary part compared with the equipment's main function.

HEAT AND COLD

Production and Application for Processes

WILLIAM J. SHORE
Engineering Consultant, New York, N. Y.

PROCESS INDUSTRIES find use for the complete range of temperatures from the lowest that is obtainable industrially, to the temperature of the carbon arc. The extremes, however, are relatively unusual and not many applications require temperatures below the freezing point of carbon dioxide, nor above the melting point of the best ceramic refractories. The range of industrial temperatures may be classified into (1) the refrigeration range, from room temperature down to the melting point of helium, which is close to the absolute zero; (2) the range of organic processing, from room temperature to, say, 600–900 deg.F.; (3) the range of inorganic processing, from 600–900 deg.F., to the highest temperatures attainable.

All of the first range may be reached by available refrigeration processes, while for the upper part of this range, evaporative cooling procedures can also be employed. For the second range, heat can be supplied by solar radiation for the lower temperatures, by electricity, by waste heat from other processes, or by the combustion of any kind of fuel. In this group, for lower temperature heating operations with heat supplied by combustion, it is often necessary to reduce the temperature level to avoid damage to the product. This can be done either by dilution of the products of combustion, or by use of a heat transfer medium such as hot water, steam, air, oil or organic liquids or vapors.

In the third range, above 600–900 deg.F., combustion of fuel is a satisfactory source of heat up to temperatures in the neighborhood of 3,000 deg.F. Even with preheated air, ordinary methods of combustion cannot yield much higher temperatures than this, except through the use of oxygen-enriched air, or by burning high-cost fuel gases such as acetylene. Hence, except for special operations such as welding, temperatures above 3,000 deg.F. are usually obtained by electric heat, either from an arc or from high-temperature resistance elements. Electricity is likewise suitable for many heating operations at lower temperatures.

HEAT PRODUCTION METHODS

No extensive comment is necessary to point out that all types of energy in use upon the earth are a product of radiant heat from the sun. These include, of course, direct radiation, the energy of falling water, and the stored radiation which is present in combustible materials.

Solar radiation has little practical interest as a source of industrial heat in the United States, a county of cheap and abundant fuel. It is used today principally in evaporating water from brine for the production of salt, and in drying various agricultural products, such as fruits, vegetables, hay and meat, as well as other food products such as fish. It has but two advantages, the fact that it involves no cost for fuel, and that it has a top limit of temperature. On the other hand, it has numerous disadvantages including part-time availability and low intensity, requiring long periods for drying operations and the spreading of materials over large areas.

Many attempts have been made in the past to utilize solar heat as a source of energy, all of which have proven largely impractical up to the present, mainly on account of the variability and intermittency of this source of heat, and the high cost of equipment required for putting it to productive use.

The eventual possibility of recovering solar energy, either as heat or directly as electricity, should not be overlooked, but at present its best applications are still in raising water for hydro power, and in growing plants for fuel.

Aside from the process heat recovered from exothermic reactions, and that which is produced electrically, processes burning fuel are the source of all process energy. Combustion processes involve the fuel itself, the burner, the combustion space and the final heat absorber. Although there are many fuels used in the process industries, the ones of principal interest are coal and coke, oil and gases.

Coal—Coals range in age from anthracite through semi-bituminous, bituminous and subbituminous of various grades to the lignites and brown coals. The great bulk of all coal used industrially is in the bituminous range. To a small extent, coal is still fired by hand on grates but most of it is burned mechanically, either using stokers of the chain-grate or under- or over-fired types; or burned in pulverized form in combustion chambers, or directly in the equipment heated, in cases where the presence of ash in the product is not disadvantageous. An instance of this latter type is the use of pulverized coal in firing cement kilns. A method of pulverized coal burning which has been demonstrated successfully on an experimental basis is firing in radiant tubes, similar to the radiant tube firing of gas.

Numerous advantages have resulted in the increasing use of pulverized coal as a fuel, particularly for the continuous production of steam in large volume. Burned in this way the combustion is highly efficient, requiring excess air amounting to only about 20-30 percent as compared with 100 percent on the average for other methods of firing coal. Not only is this important from the standpoint of thermal efficiency, but it also yields higher flame temperatures, permitting the transfer of correspondingly greater amounts of heat for the same absorbing surface. The cost of coal

on a B.t.u. basis is less than that of any other variety of fuel. In addition, the supply is ample and reserves are so great that little variation in price is likely.

Along with its many advantages, coal suffers corresponding disadvantages. Since coal is a solid fuel, it involves handling labor and storage, as well as ash disposal. In the case of pulverized coal, there is the additional problem of fly ash which often causes local complaints. Pulverized coal systems require competent supervision and operation. Owing to their cost, they are not suitable for small heat applications. An additional difficulty often arising from powdered coal use is the necessity for using the best grade of refractories, while such fuel means relatively high maintenance, owing to high furnace temperatures and slagging tendencies.

Oil—At present petroleum is the only source of fuel oils in the United States. As used industrially, fuel oils are of two principal varieties, the light grade generally known as furnace oil which may be used without preheating; and the heavy grade known as bunker C which ordinarily cannot be justified in applications requiring less than 15 g.p.h. per burner since it requires preheating to reduce its viscosity sufficiently for atomization. The latter oil sells for approximately 50-60 percent of the cost of light oil.

Oils are burned industrially with many types of oil burners, all of which, however, are variations of three general types, including mechanical atomization produced by centrifugal force or by pressure of the oil at the nozzle; air jet atomization, with or without pressure at the nozzle; and steam jet atomization, also with or without pressure at the nozzle.

Next to coal, bunker C oil is the cheapest fuel on a B.t.u. basis, except in certain localities and under peculiar circumstances. Changes in the circumstances of oil use throughout the world cause it to be far more variable in cost than other fuels. Although there is yet no real evidence of depletion of oil reserves, that possibility is always present.

Oil is easily burned, easily controlled, requires no labor for use and presents no disposal problem. It is easily stored and handled and may be burned effectively in quantities of 1 gal. per hour and more.

Gas—The gases of greatest interest from an industrial standpoint include coal and coke oven gas, water gas, carburetted water gas, producer gas and natural gas. Aside from natural gas and the cracked oil vapors added to carburetted water gas, the other gases mentioned are all direct derivatives of coal.

Gas may be burned using its own pressure drop to inspirate the necessary air for combustion, or it may be burned in fixed ratio with air, both air and gas being supplied to the burner under pressure. The latter method is commonly used for industrial purposes. Gas may be burned with an excess of air to produce an oxidizing flame, or with a deficiency of air to produce a reducing flame. If gases containing hydrocarbons are burned under reducing conditions, a luminous flame results owing to the cracking of the hydrocarbons and the liberation of free carbon particles which then burn luminously. Non-luminous flames are produced by gases containing no hydocarbons, or by those burned under oxidizing conditions. Gas may be burned within the space of a combustion chamber, it may be burned in contact with refractory surfaces which produce an apparent catalytic effect in accelerating the combustion, or it may be burned within tubes which serve as muffles to isolate the products of combustion from the furnace.

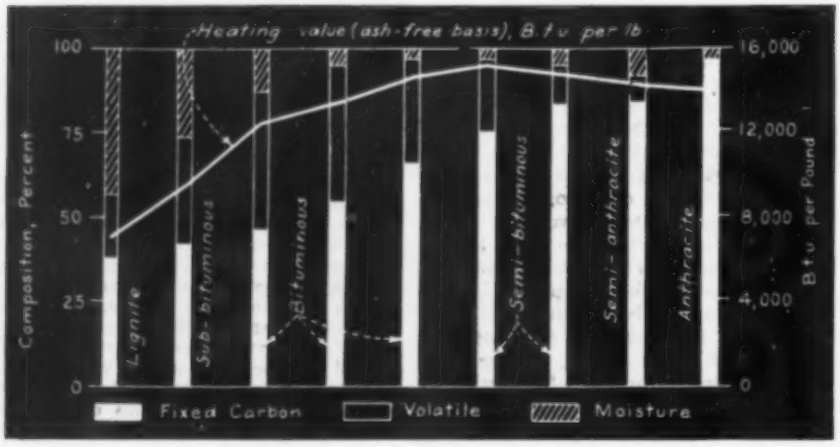
Gas fuels are being used increasingly for industrial applications because of their many desirable features. No storage by the purchaser is required, fuel is easily piped to any point of use and its burning is adapted to either hand or automatic control. Gases generally remain constant and uniform in composition, thus assuring uniform results. Price fluctuations are seldom encountered. Short of a national emergency, the delivery of gas is reasonably certain.

Characteristics of Fuels[1]

Fuel	Net B.t.u. Per Cu. Ft., S.C., Dry	Theoretical Air, Cu. Ft. per Cu. Ft. Gas	Theoretical[2] Flame Temperature, Deg. F.
Hydrogen	275	2.38	4,010
Carbon monoxide	323	2.38	4,475
Methane	912	9.52	3,750
Ethane	1,612	16.67	3,820
Propane	2,309	23.80	3,840
Butane	3,010	30.95	3,870
Ethylene	1,541	14.29	4,250
Acetylene	1,433	11.90	4,770
Benzene	3,577	35.70	4,110
Coke oven gas	538[3]	5.28	3,860
Water gas	285[3]	2.28	4,167
Carb. water gas	529[3]	4.85	4,090
Producer gas	129[3]	1.08	3,050
Natural gas	946[3]	10.04	3,740
	B.t.u. per Lb.	Lb. per Lb.	
Coal[3]	12,410	9.53	3,960
Coal tar[4]	15,827	12.05	4,050
Bunker C oil[3]	18,410	14.43	3,900

[1]From Haslam and Russell, "Fuels and Their Combustion," McGraw-Hill, 1926, except as noted. [2]With theoretical air, not corrected for dissociation. [3]Saturated at S.C. (60 deg. F. and 1 atm.). [4]From Trinks, "Industrial Furnaces," 2 ed., vol. 2, Wiley, 1942.

Fig. 1—Approximate compositions and heating values of various coals on an ash free basis (after Campbell, U. S. Geol. Survey, P. P. 100-A)



Gas fuels have a number of disadvantages although these are usually of minor importance. Natural gas is limited to certain sections of the country, and in some localities, wells have run dry. Coal and coke oven gases and carburetted water gas are relatively high in cost on a B.t.u. basis compared with coal fuels. In the case of producer gas, this gas is ordinarily made by the user who therefore has the problem of constant labor attendance, high initial capital investment and the difficulty of assuring operation at all times at the best production rate.

The possible presence of harmful concentrations of sulphur is a disadvantage of all fuel gases. Furthermore, gases are toxic and capable of producing explosions under improper conditions of use, demanding use of adequate safety appliances and better control devices which add to the expense of installation.

FLAME TEMPERATURE

Theoretically the temperature produced by the burning of any combustible material is equal to the sum of the potential heat in the fuel, plus the sensible heat in the fuel and all air supplied for combustion, divided by the average specific heat of the combustion products, multiplied by the total weight of the combustion products. The table lists the net (low) heat of combustion of several pure gases, as well as average values for a number of other fuels. In each case the table also lists the theoretical air required for combustion and the theoretical flame temperature that would be produced if there were no dissociation of CO_2 and water vapor, if the fuel were burned instantly and without radiation to the surroundings.

Sometimes a high flame temperature is not desirable, but ordinarily, within the limitations imposed by existing construction materials, the highest temperature possible is desired since this makes possible a higher heat transfer rate and usually permits a higher efficiency of fuel utilization. Accurate measurement of actual flame temperature is difficult. According to Professor Trinks ("Industrial Furnaces," Wiley 1942) actual flame temperatures without preheating of the air will ordinarily be in the range from 48 percent under the worst conditions, to 75 percent of the theoretical temperature under the best conditions.

Data on approximate heating values of various coals on an ash-free basis are given in Fig. 1, which shows also approximate compositions.

One reason why actual flame temperatures are less than the theoretical is because fuels are rarely burned with theoretical air but rather with an excess or deficiency. Excess air means introduction of more inert nitrogen to be heated to flame temperature, while a deficiency means incomplete combustion. Other reasons include dissociation and the fact that flames lose heat to their surroundings, both by radiation and by convection.

Various ways are available to increase the actual flame temperature. The most obvious is to use the smallest possible quantity of excess air, which demands the best possible mixing of air and fuel. Another is to speed up the combustion as much as possible, which can be accomplished by improving the mixing and in some cases by surface catalytic effects, by scrubbing the fuel-air mixture vigorously over incandescent surfaces, usually, refractories. A method ordinarily impractical for industrial use, except in welding, is to use oxygen, or oxygen-enriched air for combustion. A practical means which is much used is to preheat the air, or both air and fuel.

With a theoretical flame temperature of about 3,900 deg. F., proper design of the burner and installation permits actual oil flame

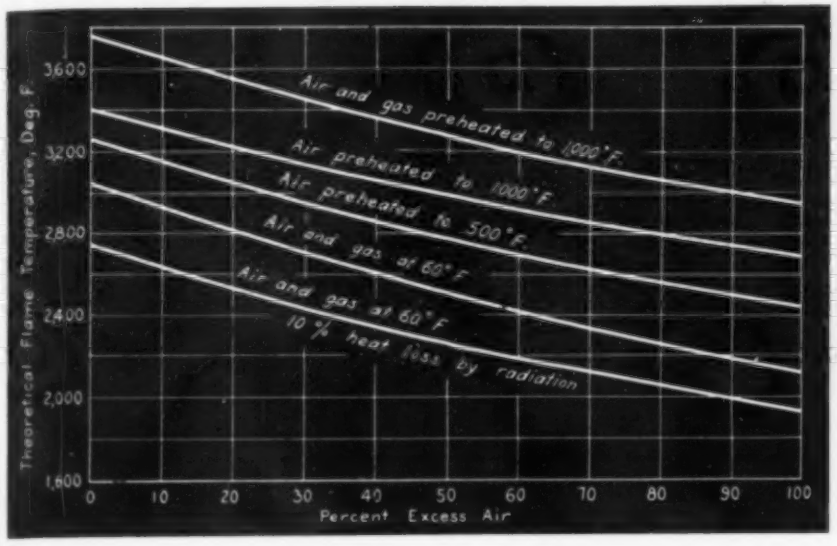


Fig. 2—Effect of preheat and excess air on theoretical flame temperature in burning producer gas, neglecting dissociation (after Haslam and Russell)

temperatures to reach about 2,400 deg. F. without preheat. Water gas temperatures without preheat, theoretically over 4,100 deg. F., will actually reach about 2,600 deg. F. with proper design. With preheat, the flame temperature can be raised to more than 3,000 deg. F. Producer gas gives a theoretical flame temperature of only about 3,000 deg. F., but producer gas is ordinarily burned with preheated air. An idea of the effect of both preheat and excess air on the burning of producer gas can be gained from Fig. 2 (after Haslam and Russell, "Fuels and Their Combustion," McGraw-Hill) which shows theoretical flame temperatures under various conditions, neglecting dissociation of the CO_2 and water vapor. At temperatures ordinarily reached in industrial furnaces, dissociation is a small factor in the reduction of flame temperature.

Use of proper burner and furnace design to insure good mixing, employment of catalytic surface effect (surface combustion) and preheating of the air (or air and fuel) by heat exchange with the flue gases are methods commonly practiced for increasing flame temperatures. Regenerators, in which heat from the flue gases is stored in refractories or metal, and later transferred to the combustion air, are used in many air preheating operations such as glass tanks, coke ovens, pipe stills, blast furnaces and open hearth furnaces. Recuperators, in which heat is transferred directly from the flue gases to the combustion air through heat exchange surfaces of metal or silicon carbide are used for air preheating for steam boilers and various kinds of industrial furnaces. Flame temperatures of well over 3,000 deg. F. are obtained in these ways.

FLAME RADIATION

As already noted flames may be either luminous or non-luminous. A luminous flame indicates the relatively slow combustion of particles of incandescent carbon produced by cracking of the hydrocarbons in the fuel. The maximum amount of radiation is obtained from a flame of this type. Under proper burning conditions the flame can be made to fill the entire combustion space. Slow, lazy flames of this type are used in special operations such as puddling iron and melting glass-making materials. The flame radiates heat directly to the surface of the material and, being of lower temperature than a non-luminous flame, gives time for penetration of heat into the interior of the material without surface damage. On the other hand, such a flame is often undesirable on account of its lower temperature which results from cracking. Furthermore, the flame is reducing in character and may be wasteful of fuel as well as non-uniform in temperature. An excess of fuel is needed to maintain this condition.

Non-luminous flames are practically invisible, or blue in color, and since they contain no luminous solid particles they radiate less heat than luminous flames. Radiation from a non-luminous flame is chiefly from the carbon dioxide and water vapor in the combustion products. A non-luminous flame is ordinarily of higher temperature than a yellow flame, indicating more complete and more rapid combustion. The flame is oxidizing in character and is generally accompanied by a considerable excess of air which will, of course, decrease its efficiency. The heat in the combustion products is transferred to the walls of the combustion chamber mainly by convection. The walls thus become incandescent and radiate heat to the product whereas, with a luminous flame, which is relatively opaque to radiation, the flame itself tends to blanket wall radiation from the product.

A non-luminous flame loses about 10 percent of its heat by radiation while, according to Helmholz, the radiation from luminous flames is 20 to 120 percent greater. In general, according to Haslam and Russell, the radiation from a luminous flame is 10 to 40 percent of its potential heat, depending on the luminosity and the flame temperature. H. C. Hottel (private communication) points out that the overall opacity of the flame is a determining factor in establishing the importance of radiation. In small systems, and when the flame does not radiate strongly, the radiation received by solid surfaces is largely proportional to the flame volume. However, with a large gas mass and/or a highly radiating flame the radiation received by solid surfaces is largely proportional to the receiving surface, so in this case, advantage is gained in increasing the surface with walls, extended surface, etc.

From the heat transfer standpoint, powdered coal flames are similar to luminous gas flames in that they consist of enormous quantities of luminous particles which, however, are fewer and larger than those in gas flames. Thus the flame transfers somewhat less heat by radiation than the luminous gas flame and also has somewhat less blanketing effect in preventing wall radiation from reaching the product.

COMBUSTION SPACE

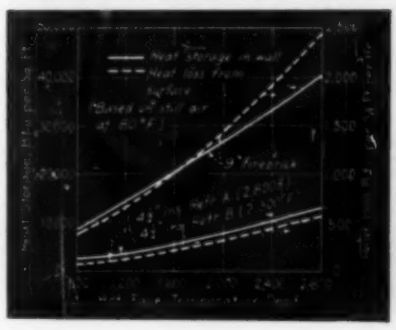
All fuel burning applications require a combustion space, the volume of which will depend on the rate of fuel burning, as well as on the fuel and its method of burning. In a cement kiln or direct-fired rotary dryer, the combustion space is the firing end of the kiln or dryer itself. In a boiler furnace, the combustion chamber may be a space largely surrounded by refractory, or it may be almost completely inclosed by surfaces which absorb the heat and transfer it to the water. In various types of indirect-fired equipment, the combustion chamber may be separated completely from the product by means of heat transfer surfaces such as muffles. Primarily, the inclosure in which combustion takes place has the functions of preventing loss of heat to the surroundings and of controlling the directions in which the heat is radiated from the flame. Its walls serve to re-radiate heat to the product. Through proper combination of heat absorbing surfaces, refractory surfaces and insulation, the combustion chamber accomplishes these purposes and tends to maintain constant temperature.

Most commonly the walls of the combustion space consist largely of refractory materials, insulated on the outside. However, many modern types of boiler furnace surround the combustion space almost completely with boiler tubes, while the old Scotch marine boiler likewise incloses the flame in heat absorbing surface. Decisions as to the relative proportions of heat absorbing surface and refractory depend considerably on the combustion conditions since an excess of heat absorbing surface, with little or no refractory, will cause such rapid heat transfer from the flame to the metal surface that the flame will be cooled excessively, and combustion will rarely be complete. The usual practice with furnaces inclosed largely with heat absorbing surfaces is to preheat the air to insure sufficient flame temperature.

Improvements in refractory making in recent years have resulted in the development of insulating refractories which not only possess high refractory quality but also excellent insulating value and low specific heat. Combustion chambers are generally built (1) of common firebrick, backed up by common brick; (2) of firebrick backed up by insulatiug brick and a sheet metal casing; or (3) of insulating firebrick backed up by a sheet metal casing.

Now that insulating brick and insulating firebrick are available, the construction chosen usually depends on the heat storage characteristics desired in the furnace. A comparison of both the heat storage and heat loss of a fire-

Fig. 3—Comparison of heat loss and heat storage for two furnace walls at various hot-face temperatures



brick wall and a wall of insulating refractories (based on data of the Babcock & Wilcox Co.) is shown in Fig. 3. For intermittent service, the tremendous amount of heat that would be stored in a solid firebrick wall, or one of firebrick backed up by common brick, would result both in excessive heating-up time and in a great loss of heat when the furnace was shut down. On the other hand, this heat-storage "flywheel" is desirable for continuous duty and the use of cheap fuels. In boiler furnaces which are subject to sudden heavy loads, as in the heating of pulp digesters, a large heat storage capacity is essential. For maximum heat storage, therefore, the wall must be heavy, made of materials of high specific heat. For less heat storage, firebrick and insulating brick suffice, while for least heat storage, insulating firebrick backed up by sheet metal is most desirable.

VOLUME AND DESIGN

The relation between combustion chamber volume and rate of fuel firing varies widely, depending on the type of furnace, the fuel and its method of firing. In powdered coal fired furnaces Kent recommends a rate of heat release not greater than 20,000 B.t.u. per cubic foot of furnace volume per hour with refractory furnaces in continuous operation; not more than 15,000 B.t.u. for low-fusion ash; and not over 35,000 B.t.u. in furnaces with water-cooled walls. On the other hand, central station practice using pulverized coal goes as high as 60,000 B.t.u. Burning coal on underfeed stokers, the rate is generally not over 50,000 B.t.u. For oil fuels, Kent suggests 30,000 to 100,000 B.t.u. for industrial furnaces, although in special cases the heat release is as high as 250,000 B.t.u. per cubic foot per hour.

The range of heat release for gas is particularly wide. Practice suggests release rates from 30,000 B.t.u. per cubic foot per hour with atmospheric burners, to a maximum in the range of 200,000 B.t.u. with usual forced draft burners; and from 700,000 B.t.u. to ten times this amount with special types of combustion employing surface catalysis. The last mentioned figure, of around 7,000,000 B.t.u. per cubic foot per hour, is claimed to be attained under certain conditions using the cup-type refactory burners manufactured by the Selas Co.

Combustion chamber shapes vary with the fuel and somewhat with the method of firing. With hand-fired coal, the chamber is ordinarily a rectangular prism lying on its side. For coal fired on stokers, a similar shape is generally used for chain-grate stokers, while with underfeed stokers the prism generally stands on end. For pulverized coal, the chamber is usually square in section and about twice as high as the sectional width. In boiler furnaces this prism generally stands on end. For oil and gas fuels firing boiler furnaces, the chamber is usually cubical or prismatic, but where they can be used, tangential and hairpin-loop combustion chambers, such as those shown in Fig. 4, are most efficient since these designs allow a long flame travel and give a harsh and violent scrubbing action of the fuel mixture and the combustion products against the sides of the refractory, insuring complete combustion and the release of all heat energy within a concentrated space. Long single-direction combustion chambers for oil and gas fuels are usually highly inefficient, with a considerable part of the heat released in the flue as indicated by high stack temperatures and a low rate of heat transfer.

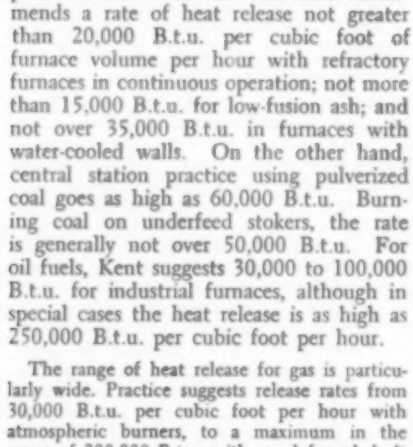


Fig. 5—Radial distribution in front of three Selas incandescent ceramic-cup gas burners, compared with theoretical distribution from a small flat radiating disk

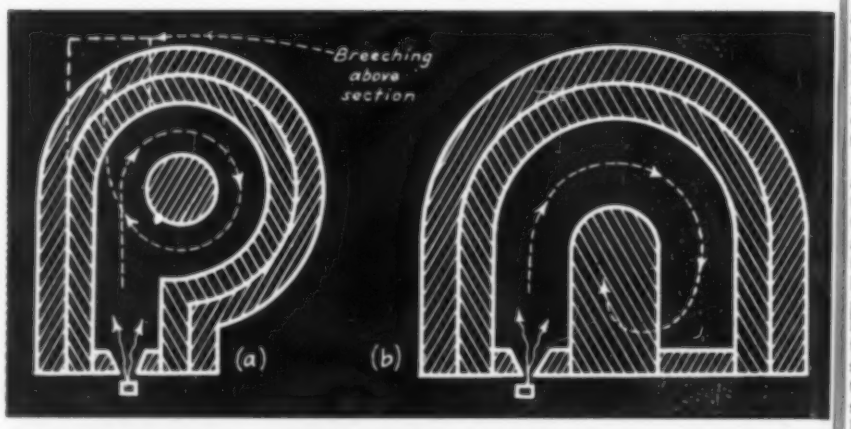


Fig. 4—Tangential *(a)* and hairpin loop *(b)* combustion chambers for the burning of gas and oil fuels

In addition to the conventional types of combustion chambers, many special types are used for gas. In general, these may be classified as muffle types, radiant and immersed tubes and various applications of surface catalysis. Where it is desired to prevent the products of combustion from coming into contact with the ware, the gas-fired radiant tube type of muffle is often employed, consisting of a long tube of metal, alloy metal or refractory into which the burner fires. This method doubtless gains the advantage of a surface catalysis effect in the firing zone, at the same time giving good convection from the combustion products to the tube in the convection section, owing to turbulence and high velocity. In some applications such tubes are operated immersed in liquids being heated, while in other cases they may be coiled back and forth over the walls of furnaces.

In applications where a high radiant transfer is required and the combustion products can be permitted in contact with the ware, a variety of surface catalysis methods are employed. A method less used now than formerly is to fire into a bed of lump refractory which creates high turbulence in the incoming gases and doubtless accelerates combustion also through surface catalysis. Another method is to fire into a refractory tunnel within the furnace walls so that combustion is largely completed by the time the gases issue into the furnace. Burners of the Selas and Burdette types employ refractory cups having a multiple-nozzle burner at the center. In the Selas design, the refractory cup is finely ridged circumferentially so as to improve turbulence and give incandescent heated points. Although the cup is shallow, even in large burners it is claimed that combustion is completed before the gases leave the cup. Fig. 5 presents new data on the radial distribution of radiant heat in front of three sizes of burner of this type, compared with the theoretical distribution from a flat radiating disk.

ELECTRIC HEAT

Electricity is used in a number of ways for the supply of process heat. For example, it may be used to produce heat at an extremely high temperature, as in arcs and in heating lamp filaments, which is thus available for transfer largely by radiation to the product. Electricity can be passed through the product itself, if this is electrically conducting; through the container; or through resistors which may be in direct or indirect contact with the product, thus producing heat through resistance loss. This type of heating can be accomplished either by passing the current direct from the source through the element serving as the resistor, or it may be accomplished by inducing a current in the element by transformer effect. Finally, there is the newest type of electric heating known as dielectric heating, in which heat is produced in a non-conducting product by making it the dielectric in a condenser subjected to a rapidly alternating potential.

Resistors—Cases in which the resistance of the product itself is used include some types of electric boiler, metallurgical salt baths, and some cases of electrolysis of molten electrolytes. The container itself or a pipe line is sometimes used as the resistor with a low-voltage, high-amperage current. However, separate resistors are most commonly used. These are of two types, the sheathed and the unsheathed. Sheathed resistors are either immersed in the material to be heated or strapped on to the sides of the container. Resistors for high temperature work are ordinarily unsheathed, consisting of alloy wire, castings or strips, or rods of carbon or silicon carbide. Carbon (graphite) resistors are used at temperatures up to 3,500 deg. F. Silicon carbide resistors can operate continuously at 2,600 deg. F. and for short periods up to 3,000 deg. F. Most metallic resistors do not operate at higher than about 2,000 deg. F. For such temperatures, alloys of nickel and chromium, sometimes containing iron, are used. Special metallic compositions, however, have been developed for temperatures as high as 2,500 deg.

With resistors operated at temperatures above 1,000 deg. F., transfer by radiation becomes increasingly important. Owing to the fact that there is no flue gas loss with electric heating, this method often has an efficiency as high as 95 percent, thus making its cost on a B.t.u. basis comparable with that of fuels.

Sheathed heaters are frequently strapped against the outside surface of process vessels, transmitting their heat by conduction through the vessel wall. Since radiation takes place in all directions from the heating element, particular care must be taken in insulating the heaters and the vessel from the outside to prevent heat loss. The efficiency of this type heater is not as great as that of the immersion type and a loss of 15 to 25 percent to the surroundings must be anticipated. In most types of electric heating, a high grade of insulation is ordinarily required to offset the high cost of energy.

Arcs—Arcs are used to supply heat in the production of phosphorus and in metal-melting

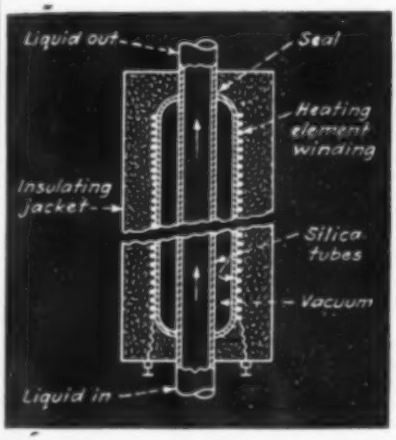


Fig. 6—Diagrammatic sketch of Reavell infra-red evaporator tube

furnaces. Under proper conditions they produce temperatures as high as 6,000 deg. F. or even higher. Most of the heat from the arc is transmitted by radiation. Many different arrangements have been employed including single-, two- and three-phase arcs, as well as two- and three-phase arcs using the container and/or charge as one electrode.

Lamps—In recent years there has been increasing interest in the use of radiation of wavelengths concentrated in the infra-red region for heating purposes. High temperature resistance elements, of course, also transmit most of their heat by radiation. Heating lamps have recently become popular for surface heating applications, such as the rapid drying of synthetic finishes on metallic products; and to a lesser extent for the drying of chemicals. Such lamps are glass-inclosed and make use of a tungsten or sometimes a carbon filament. Lamps are provided with polished metal reflectors, either separate of the bulb or applied directly to the glass. Since the filament may operate at temperatures as high as 4,200 deg. F., most of the radiation is in the infra-red range, with only 8 to 10 percent of the total energy in the visible range. Such lamps are made in capacities from 100 to 1,000 watts.

This method of heating has not been used long enough to permit appraisal of its possibilities beyond a rather narrow range of uses. It is apparent that the method is applicable only to products which are relatively good absorbers of radiation, which would exclude materials of low emissivity.

A novel application of infra-red radiation has recently been described by J. Arthur Reavell in a paper presented before the Institution of Chemical Engineers in London. He has developed and patented a method of heating liquids for evaporation by radiant energy transmitted through fused silica tubes from a radiating, electrically heated filament. A typical form of his apparatus is indicated in Fig. 6. It is claimed that with a time of contact of only a matter of seconds, it is possible to obtain a concentration of the order of 50 percent with a single passage through the infra-red generator.

A somewhat similar method of evaporation, using gas as the source of heat energy, has recently appeared in an application made in the United States by the Selas Co. In this case radiant-cup gas burners were employed to transmit heat through Pyrex glass tubing through which a corrosive liquid flowed rapidly. Here again the heat transfer is to a considerable extent by radiation.

Induction—Induction heating is used largely for metal melting and less frequently for chemical purposes. An induction furnace is in effect a step-down transformer in which the material being heated or its container serves as a short-circuited secondary. In 60-cycle low-frequency furnaces of the Ajax-Wyatt type, used for brass melting, the primary coil, wound on an iron core and surrounded by a refractory sheath is submerged in the bottom of a vessel containing molten metal. A narrow passage extending beneath the primary completes the secondary circuit of molten metal around the primary.

In the moderate-frequency induction furnaces of the Ajax-Northrup type, no core is required. Furnaces of this type use frequencies of 360 to 2,000 cycles per second or higher. The primary current flows in a helical water cooled coil inducing the heating current in a secondary consisting either of a conducting vessel placed within the coil, or the material itself. Electric induction heating of this type has been employed to some extent in heating chemical process vessels, and to a large extent in metal melting, particularly where relatively small amounts are to be melted.

High frequency induction, using frequencies of around 10,000 cycles, produced either by high frequency mechanical alternators or electronic alternators, is now being employed to a large extent for surface heating of metallic objects for heat treatment. The principle is the same as the medium frequency induction method. The capacity of the equipment is determined by the number of turns in the primary, multiplied by the input capacity in amperes. The rate of heat input to the material is directly proportional to the square root of the product of resistivity and frequency. For magnetic materials, the heat input is directly proportional to the square root of the product of resistivity, frequency and permeability. Below a capacity of 15 kw. the equipment cost for an electronic tube generator is less than that for a high frequency motor-generator set.

Dielectric Heating—Dielectric heating is now being used in the preheating of plastic preforms, heating of plastic materials for injection molding, and in the curing of plywood and compressed plywood. It appears to have possibilities for other purposes, including certain drying operations and the heat-bonding of materials of good heat insulating quality. This method, applied to materials which are non-conductive of electricity, enables heat to be put into the material without the necessity for transferring heat from the outside. Owing to the condenser loss effect when a non-conductor is placed between plates subjected to a high frequency alternating potential, heat is produced directly in the material which can be raised rapidly to any temperature desired. This method is limited to an overall thermal efficiency of about 50 percent from power input to heat in the product. Equipment so far built has been supplied in sizes up to 600 kw. input. The heat produced in the product is proportional to the square of the voltage and to the frequency, capacity and power factor of the material. Voltages in the range from 1,000 to 10,000 are used, with frequencies in the range from 1,000,000 to 10,000,000 cycles. These high frequencies are readily produced by means of vacuum tube generators. Fig. 7 is a simplified diagram illustrating the principles of such a circuit. A circuit of similar type may be used for high frequency induction heating, with a coil substituted for the electrodes and dielectric material shown in Fig. 7.

COOLING PROCESSES

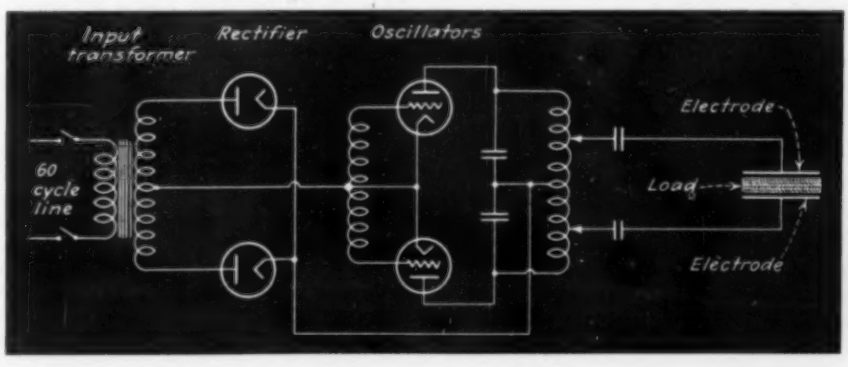
In most applications, industrial cooling procedures can be considered as falling into three classifications: (1) cooling from natural sources; (2) cooling with "stored cold"; and (3) cooling by evaporative means.

Natural Sources—Natural cooling water accounts for the bulk of industrial cooling in this classification. Next to this comes air, Water which has been cooled by allowing a part of it to evaporate into the air is a third source of cooling, while a comparatively small amount of cooling is accomplished by natural ice.

Stored Cold—Cooling can be accomplished by artificial water ice and brine ice, and by solid and liquefied gases. Practically, water ice accounts for the bulk of cooling of this type, although salt ice has some application. A salt solution of 23.3 percent NaCl will freeze to a eutectic temperature of −6 deg. F., yielding an ice having a latent heat of fusion of 101 B.t.u. per pound, compared with 144 B.t.u. for water ice, but suitable for lower temperature.

Liquefied Gases—For cooling to extremely low temperatures, as for example in the cold traps employed in evacuating to pressures considerably below 1 micron, liquid air is some-

Fig. 7—Simplified diagram of typical dielectric heating hook-up



times used. Liquid air boils at −304 deg. F., slightly higher than the temperature of −321 deg. F. at which nitrogen boils. A considerable use has developed in recent years for the refrigeration that can be obtained from liquid carbon dioxide by use of its expansion product, solidified carbon dioxide or dry ice. Dry ice sublimes without melting at −110 deg. F. and is used for cooling metals for shrink fitting and for the artificial aging of aluminum alloys.

Evaporative Cooling—Although the term evaporative cooling is generally taken in a narrower sense, practically all industrial refrigeration processes extract heat from materials being cooled by allowing either a refrigerant gas in the liquefied state, or the material itself, to evaporate, thus lowering the temperature by removing the latent heat of evaporation. Another characteristic of evaporative cooling processes is that they are able to extract heat at a low temperature and discard it at a higher temperature, thus "pumping heat uphill."

Compression Refrigeration—If a suitable vapor such as ammonia, sulphur dioxide, one of the Freons, methyl chloride, propane or any one of a number of other compounds, is compressed and then cooled in a condenser to remove the heat of compression, the material will condense to a liquid which is then allowed to expand through a valve into an expansion coil or evaporator where the material revaporizes, extracting the latent heat of evaporation from its surroundings. This simple vapor compression cycle is the most commonly used refrigeration method where temperatures much below atmospheric are required. A number of variations of this process have been introduced to permit dispensing with the compressor. The commonest of these is the absorption system. Continuous absorption systems use a liquid solvent for the refrigerant vapor instead of a compressor, while intermittent systems generally employ a solid adsorbent for the vapor, usually silica gel. These systems release the refrigerant vapor under pressure when heat is applied to the solvent or adsorbent. The vapor is then condensed to a liquid by a heat exchange with cooling water and the liquid allowed to expand through a valve into an expansion coil where its evaporation absorbs heat as in the case of the compression cycle. Ammonia is the commonest refrigerant for industrial use although others are used where there are special requirements.

Spray Ponds—When water is brought in contact with air which is less than saturated, evaporation of some of the water takes place, the latent heat of evaporation being provided in considerable part from the water itself, provided that its temperature is above the wet-bulb temperature of the air. If the water is sprayed into moving air above a pond, the evaporation will be more rapid than from a continuous water surface, owing both to turbulence and to the tremendous increase in surface resulting from atomization. The water will give up close to 1,000 B.t.u. of sensible heat for each pound evaporated in spray ponds and other evaporative coolers.

Cooling Towers—If instead of spraying water more or less uncontrollably into the air above a pond, it is sprayed on to surfaces inside a tower through which air is moving, the same kind of cooling effect will be obtained. Cooling towers are of two principal types, natural draft and mechanical draft. In the first type, the sides of the tower are constructed of splash boards arranged like louvers to permit through circulation of the breeze, while in the second type the walls of the tower are solid except for the inlet and a fan either at the bottom or at the top circulates air upward through the tower. To present the maximum possible amount of water surface to the air in both types, packings which are generally of wood are provided in various forms and shapes. These are designed to offer minimum resistance to air flow while presenting the greatest possible water surface. Cooling towers generally permit cooling water to within 5-10 deg. of the wetbulb temperature of the air. They are employed primarily where water is scarce or expensive or where its mineral content is unfavorable for use in condensers and other cooling processes.

Evaporative Coolers—If a cooling surface such as a condensing coil is placed in the bottom of a cooling tower where it will be showered by the water which has been cooled above, the equipment can be classed as an evaporative cooler. This procedure is sometimes used in the petroleum industry. A recent application of the same idea on a smaller scale has become popular for use in condensing and process cooling where the available water supply is expensive or poor. Such equipment is built in relatively small units, complete with fan and water circulating pump. It consists of a cooling or condenser coil of the extended surface type, over which recirculated water is sprayed while air is blown across the wetted surfaces by means of a fan. Material to be condensed or cooled circulates through the coil.

Flash Cooling—In a cooling tower the mechanism of water evaporation is the sweeping effect of unsaturated air. More rapid evaporation of the water and lower water temperatures (even to the freezing point) can be attained by substituting the action of a vacuum pump for the sweeping effect of unsaturated air. Both steam jet ejectors and mechanical vacuum pumps of the centrifugal type are used for this purpose. In this case the water is caused to boil at a sub-atmospheric temperature such as 40 deg. F. by maintaining a low pressure above its surface and mechanically removing water vapor from the vapor space as rapidly as it is released from the water. This method is used for cooling process liquors by evaporation of part of the water, as well as for absorbing the heat picked up by circulating cooling water in cooling processes, and in air conditioning.

The only remaining cooling processes not mentioned above are of little practical interest in ordinary cases. It is possible to produce refrigeration without liquefaction of the refrigerant by compressing the gas, removing the heat of compression in a cooler and allowing the cooled, compressed gas to expand, either through an orifice or against a piston. In either case the gas will be cooled and can be used as a refrigerant. Liquid air is produced by both methods, and the second method is used to some extent aboard ship for refrigeration, owing to the fact that the refrigerant (air) is non-toxic and non-flammable.

HEAT TRANSFER

The first part of this article dealt with heating and cooling processes. The remainder is concerned with the transfer of heat to and from the product, primarily without special heat transfer media. (A separate article discusses media transfer.—Ed.) When heat flows from a hot source to the product, the operation is known as heating. When heat flows instead from the product to a source of lower temperature, the operation is known as cooling, if the low temperature source is in the range of atmospheric temperature, or as refrigeration, if at a much lower temperature.

Heat transfer is direct if heat flows directly from the source of heat to the product (or from the product to the cold source). The transfer is indirect if the heat must flow through a dividing wall, such as the wall of a pipe or kettle. Generally the presence of such a wall is disregarded in naming a particular case of heat transfer, such as a "liquid-liquid" heat exchanger. Actually, of course, such an exchanger involves transfer of heat from a liquid, through a film, through a wall, through a second film, and into a second liquid. Direct application of heating and cooling media to the product is always more effective and efficient where it can be done. Elimination of separating walls reduces time, minimizes the weight of materials needed and lowers cost for fuels, refrigerants and power.

As has been pointed out in a previous article, heat is transferred by conduction through solid materials, in which case there is an exchange of kinetic energy between the molecules at the high temperature side and those in the direction of lower temperature, by convection in fluid systems, when there is actual transportation of material which has been heated to a higher temperature, into regions in which the temperature is lower; and finally, by radiation, in which energy is given off by molecules at higher temperatures and can be received by molecules at lower temperatures without the need for any intervening medium. There is considerable doubt in the author's mind whether convection is properly a part of heat transfer or whether it should not be regarded simply as a case of fluid flow in most instances. In any event, heat transfer by conduction and convection depends principally on the difference in temperature between the higher temperature material and the lower temperature material, while heat transfer by radiation is influenced by temperature level as well as by temperature differences. In systems in which fluids are present, conduction and convection inevitably go hand in hand. Radiation may be a minor factor, and generally is, at lower temperatures. The point at which radiation becomes the controlling factor in a given heat transfer problem depends upon the interrelation between conductivity and convection coefficients on the one hand, and the temperature and emissivity of the high and low temperature materials on the other. Hottel has pointed out that this point may be as low as room temperature for a large bare steam pipe passing through a room where the air circulation around the pipe is by natural convection.

Heat transfer problems involve many variables and, except for explosions and other sudden releases of thermal energy, generally demand perceptible time for their completion. Most problems are therefore complex and do not usually lend themselves readily to simple mathematical formulas. Design methods are mainly empirical, despite the semi-theoretical correlations that have been made, and successful designs depend largely on the skillful incorporation of experience factors. Nevertheless, real progress has been made and will continue to be made.

SHAPE AS A FACTOR

Before discussing various types of heat transfer it is well to take note of the fact that the physical form or shape of both the product and the source of high or low temperature have an important bearing on heat transfer. Heat transfer to or from solids occurs most readily if the material is finely divided and in a state of suspension, which is particularly true in the range of radiation temperatures. Good heat transfer occurs with solids in sheet form and poorest transfer when the material is in bulk form and in substantial thickness, in which case the ratio of surface to volume is least. Few solids are transparent to radiation so that transfer by radiation terminates largely at the surface while the interior receives heat only by conduc-

tion. A sphere is obviously the least favorable shape, both because it gives only point contact for entrance of heat by conduction and because its ratio of surface to volume is a minimum.

Much the same considerations apply to heat transfer to liquids. The most favorable form for heat transfer is the spray, the next most favorable the condition where the liquid is canalized and subjected to rapid circulation, and the least favorable, where the liquid is in bulk form in a container, without circulation other than natural convection. Radiation is generally a less important factor in dealing with heat transfer to or from liquids than in the case of solids, owing to the fact that temperatures are usually lower. However, liquids are relatively transparent to radiation so that when radiation is a factor, the relation of surface to volume of the material being heated is less important than in the case of solids. Among the gases, only carbon dioxide and water vapor have any appreciable absorptivity for radiation so that heat transfer occurs largely by convection. As with liquids, turbulence is important. Furthermore, the improvements that are possible through recirculation are often not recognized.

In the case of cooling operations, substantially the same remarks can be made except that, in dealing with lower temperatures, radiation obviously becomes a smaller factor, while good convection is likely to be more difficult to obtain, owing to increased viscosity.

It should perhaps be pointed out that several of the methods of heating and cooling discussed previously do not involve heat transfer except incidentally. These include dielectric heating and cases where the product itself serves as an electric resistor, as well as cooling processes which function by reason of the evaporation of the product itself.

TRANSFER COMBINATIONS

It can be considered that all heat transfer processes take place between solids, liquids and gases, in any of nine possible combinations, depending on the direction of heat flow. In addition, from a heat transfer standpoint, a condensing vapor behaves differently than a gas, and a boiling liquid behaves differently than a liquid which is not boiling. Hence, it is customary to include cases for transfer from condensing vapors to solids, liquids, boiling liquids and gases; and from solids, liquids and gases to boiling liquids, thus adding another seven cases, for a total of 16.

1. Solid to Solid—Heat transfer from solid to solid can occur only by radiation and by conduction. Disregarding the numerous cases where a wall separating a solid from a source of heat or cold might be considered as one of the solids in the transfer, there are still many important examples to be found in radiation from fuel beds, powdered coal and luminous flames and from furnace walls, to solid products within the furnace. The latter include cement clinker, lime rock, ceramic products, and so on. The heating of solids by radiant lamps is an example and the transfer of heat from an arc to an electric furnace charge such as a mixture of carbon, sand and phosphate rock, is another example. Many cases are found in electrothermic industries. The important conclusion to be drawn is that good heat transfer demands high temperature and emphasis on radiation or, lacking that, good contact between the heat source and the material being heated. When neither of these is possible, a heat transfer medium such as recirculated flue gas must be used to effect a transfer mainly by convection.

A number of examples also are to be found in the case of cooling. Ice, eutectic ice and solid carbon dioxide are used to some extent for the cooling of solid products although the examples fall mainly in the food and metal working industries. Agitating action to minimize formation of an insulating film or the use of a recirculated heat transfer medium such as air or carbon dioxide gas to promote convection, is necessary. An interesting application in metal working is the growing use of solid carbon dioxide for shrink fits.

2. Solid to Liquid—When a liquid is being heated from a solid source, radiation is likely to play less of a part than in the case of solid products. This is because in many cases lower temperatures will be used. This is not necessarily true, however, where a wall intervenes, as in the case of radiation from fuel or furnace walls to boiler tubes and thence to water. Examples in this case include transfer of heat from a container heated by resistance, to the contained liquid; radiation from lamps, arcs, incandescent fuels or furnace walls to liquids either in containers or in sight of the radiation; and radiation from special gas burners or from infra-red lamps to liquids in glass or silica tubes, as well as to the walls of metal tubes which are opaque to radiation. The chief importance of this classification from the heat transfer standpoint lies in cases where heat is being transferred from a hot wall, heated by radiation or other means, to a liquid in contact with it. It is obvious that the controlling factor is convection and that agitation and turbulence are essential factors in reducing the retarding effect of the inevitable liquid film.

Among cooling applications are several that should be mentioned. For example, the quenching of hot coke and hot metals with water or other liquids is an important case, as is the use of coolants in metal working. Initially, with material hot enough to radiate strongly, the heat transfer is largely by radiation. Since water will boil under the circumstances, absorbing about 1,000 B.t.u. for each pound of evaporation, it is obviously an excellent cooling medium, while the turbulence produced by boiling yields a good transfer coefficient. Quenching oils generally are considered not to boil, but some vaporization and cracking certainly takes place. Among examples in which an intervening wall exists may be mentioned the Thermofor kiln for revivifying filter clays, in which the heat of combustion of the oil in the clay is carried away by a high-boiling organic liquid such as Dowtherm, circulating in tubes in contact with the clay; and the cooling of the petroleum industry's fluid catalyst in suspension, by transfer through walls to cooling water. When the warmer body is at a relatively low temperature, as in many cases, radiation usually becomes negligible and convection is the controlling mechanism of heat transfer.

3. Solid to Boiling Liquid—Whenever the heat source is a solid, radiation is likely to play an important part in the method of heat transfer. Owing to the turbulence in a boiling liquid, the liquid, if in contact with the hot body or a separating wall, will have a high liquid-side coefficient of convection transfer. In the case of direct transfer without an intervening wall, there is doubtless some tendency for radiation to be absorbed by the vapor given off by the boiling liquid, especially in the case of water, thus retarding transfer by this method. Examples of direct transfer occur in the case of the transfer of heat from electrically heated vessel walls to the boiling contents of the vessel, and in the quenching of coke and hot metals by liquids. In the case of indirect transfer, through an intervening wall, the hot solid transfers heat to the wall only by radiation unless some heat transfer medium such as air or flue gas is introduced to carry heat by convection. On the liquid side of the wall, exceptionally high film coefficients will be obtained owing to turbulence. Examples of indirect transfer occur in the case of radiation of furnace walls and incandescent flames to the water in boiler tubes or to the liquid in direct-fired process vessels. It is claimed by the Selas Co. that through the use of radiant cup gas burners it should be possible to reduce the quantity of heat transfer surface in the radiant section of a tubestill by as much as 50 percent, and in the convection section by an appreciable amount, possibly 20 percent. A proposed design for such a still contemplates reducing the size of the combustion chamber to a small fraction of that needed in conventional designs, thus greatly reducing the overall space requirement. The transfer in such a still would be accomplished to a considerable extent by direct radiation from the incandescent refractories of the burners.

4. Solid to Gas—Heat transfers from solids largely by radiation, and as gases in general are poor absorbers of radiation, it is necessary in this case to transfer heat largely by convection in the face of probably unfavorable film coefficients. High turbulence is necessary. The same general principles apply in the case of indirect transfer where a wall separates the hot body from the gas. Examples of direct heat transfer occur in such cases as the heating of furnace atmospheres by radiant electric heating elements; and the pick-up of heat by air or combustion gases passing over the hot checkerbricks of regenerators. Cases where the transfer is desired for cooling occur in cement coolers; in the air cooling of ceramic ware in kilns, usually with the recovery of this heated air for subsequent use in combustion; in the dry quenching of coke with inert gases, and in the atmospheric cooling of hot objects of all kinds in the air. Cold gas from subliming carbon dioxide is also sometimes used for cooling purposes.

The cases of indirect heat transfer through a wall are similar in principle to the direct transfer just described. Examples occur in muffle furnaces where the primary radiating elements are separated by a muffle from the ware.

5. Liquid to Solid—Transfer of heat from liquids to solids occurs in several familiar examples, and yet this classification

is relatively unusual from an industrial standpoint. Heat is frequently transferred from a liquid to solid walls separating the heat source from the final receptor of the heat, but this case is not included here. Such transfer involves convection on the liquid side and conduction on the solid side. The only methods of improving the heat transfer are to improve the convection or to put the solid into more favorable form, such as finely divided, in suspension in the liquid, or in sheet form. An example of heating is found in the transfer of heat from electrically heated salt baths to metal products being heat treated. An example of cooling, familiar in the dye industry, is the use of ice dumped directly into liquid in process to control the reaction temperature. This example shows the effect of giving favorable form to the solid. Obviously, a cake of ice is much less effective than the same quantity of ice in chip or flake form.

6. Liquid to Liquid—It is unusual to find direct cases of transfer between liquids, although indirect cases are common. Direct transfer in the case of immiscible liquids involves two films without an intervening wall. The method is occasionally encountered in quenching molten products in water or other cold liquids and has occasionally been proposed as a method for transferring heat to corrosive solutions by showering a heated immiscible heat transfer liquid through the liquid being heated. The method is sometimes used in rapid cooling of a product by mixing it with a quantity of the same material which has already been cooled, for example, for the purpose of stopping a reaction.

LIQUID–LIQUID EXCHANGERS

Indirect examples of liquid to liquid transfer, where there is an intervening wall, occur in numerous cases, including process vessels heated by hot liquid heat transfer media; liquid-liquid heat exchangers of all types; chillers for the production of solidified products such as soap and caustic soda; and the use of water sprayed into a combustion chamber and on to the bottom of a direct-fired process vessel for rapid cooling. This last method might appear to be a drastic one which would result in damage to the firebrick setting and possibly to the vessel as well. Actually, it has been used successfully as in Fig. 8 (W. J. Shore, *Chem. & Met.*, 93, Dec. 1942) with good cooling results and surprisingly little damage to the setting. In all cases of indirect transfer between liquids, it is obvious that the transfer is largely by convection, involving two liquid films, and that good turbulence is necessary to minimize the resistances.

7. Liquid to Boiling Liquid—It is unusual to find cases of this type except where a wall intervenes. The controlling resistance is generally that on the non-boiling liquid side, since the turbulence of the boiling liquid results in a favorable transfer condition. Numerous indirect cases occur, for example, where high temperature liquid heat transfer media are used for the boiling of process liquids, or where an organic reaction is conducted

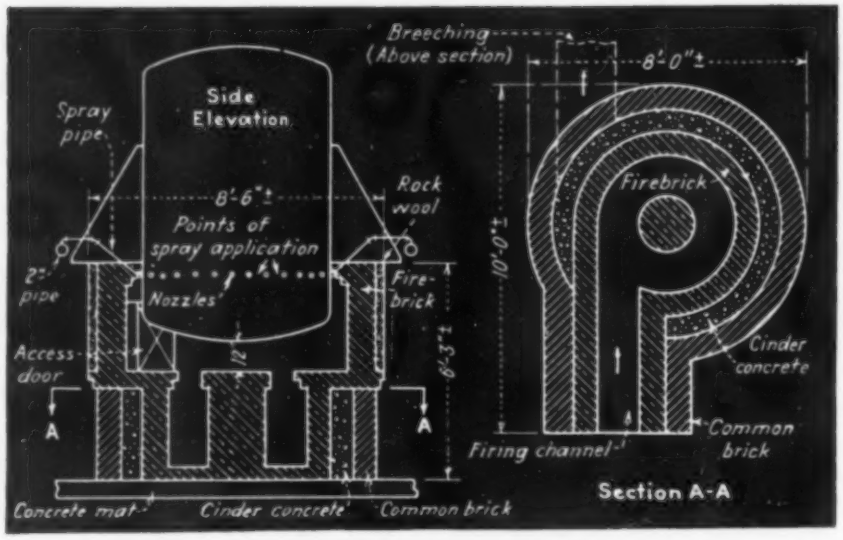


Fig. 8—Direct fired process vessel with combustion chamber similar to Fig. 4(*a*), showing nozzles for spray cooling of setting and vessel

in tubes surrounded by a boiling liquid which carries away the heat of reaction as latent heat of the boiling liquid.

8. Liquid to Gas—This classification is generally found in applications for the cooling of liquids rather than for the heating of gases. The distinction arises from the purpose of the operation. In all cases convection is the principal mechanism of heat transfer, with the coefficient on the gas side tending to be controlling. An example of a direct application is found in the heating of air, coincident with humidification, by heated spray water. Since a large interface area is necessary in such applications, spraying of the water is ordinarily required. Liquid may also be cooled by contact with gas, and there are several well known direct applications. For example, air can be used to cool a hot process liquid at the same time that it agitates the liquid. Owing to the low specific heat of the air and the unfavorable gas-side coefficient, this method is not ordinarily used except where simultaneous agitation is required. Cooling of liquids by contact with the atmosphere is, of course, an obvious example, but it is rarely used industrially today owing to its slowness and lack of efficiency and to the requirement for large surface area.

In the case of indirect transfer from liquids to gases, the gas-side coefficient is again the chief resistance and the use of extended surface on the gas side becomes justified. Examples occur in the use of hot Dowtherm for steam superheating and for air preheating, and in the cooling of process liquids by atmospheric air passed over coils.

9. Gas to Solid—The transfer applications in this group fall largely in the field of heating. Since gases in general are poor radiators heat transfer must take place largely by convection, which requires a high degree of gas turbulence for good transfer. Where it can be used gas recirculation not only aids turbulence, but it also helps to bring the mass of the gas in contact with the solids, as in Fig. 9. Improvement of the form of the solids likewise contributes to rapid transfer. For example, since the best transfer in this category takes place to solids which are finely divided and in suspension, exceptionally efficient transfer is obtained in so-called kiln mills for combined drying and grinding; and in the fluid catalyst process for petroleum refining, where the catalyst removes the heat of reaction and maintains remarkably uniform temperature in the reaction chamber. Examples of direct transfer are found in the transfer of waste heat to regenerator heat absorbing elements. Another case is in convection transfer to the solid loading of dryers, kilns, metal melting furnaces and glass tanks. Hot gases are used directly for the heating and regeneration of beds of adsorbents such as the activated carbons and mineral gels. A cooling example is found in the cooling (and dehumidification) of air by means of ice. The last mentioned application involves also a liquid film produced by the melting ice, and is accomplished more efficiently by circulating ice-cooled water which is sprayed through the air.

Indirect applications where the heat source is separated from the solid by a wall are found in various types of muffle furnace, for example, in indirect-heated rotary dryers; in coke ovens where heat is transferred from the hot gas in the flues through the refractory retort wall to the coal; and in furnaces provided with gas-fired radiant tube heating elements. Direct-fired melting operations are also included. The melting of pitch is an example. Since the contact between the hot intervening wall and the solid will generally be a series of points in the initial stage, it is usually necessary to heat slowly until a layer of melted material covers the bottom surface of the container. Otherwise, the hot spots may result not only in damage to the material from overheating but also in damage to the container.

10. Gas to Liquid—Heat transfer operations in this class tend to be controlled by the gas-side convection coefficient, thus demanding gas turbulence as well as a

favorable form for the liquid, if possible. There are many examples of this type of transfer in industry. For example, the spray drying of solutions and of dilute suspensions of solids is a familiar case. Spray dryers not only impart the most favorable form—a fine spray—to the liquid, but also project the spray violently through the gas for maximum turbulence. Another example, not much used as yet, is submerged combustion, the method of burning gas fuel in a special burner beneath the surface of liquid so as to emphasize both radiation from the flame and convection from the resulting combustion gases.

SUBMERGED COMBUSTION

In this method the combustion products find their way to the atmosphere by traveling through the liquid to be heated. An extremely high efficiency of heat transfer can be obtained. In evaporating water from glaubers salt the Ozark Chemical Co. (Douglass and Anderson, *Chem. & Met.*, 135, May, 1941) burns natural gas and secures a heat release rate of about 139,000 B.t.u. per minute or 70,000 B.t.u. per cubic foot of burner space, with about 90 percent of the heat in the gas going directly to heating and evaporating the liquid.

Other examples occur in the transfer of heat from gas flames to molten glass or metal and in the evaporation of liquids in certain rotary dryer applications. Cases where cooling of the gas is the primary function are found, for example, in direct contact coolers for hot sulphur dioxide where the cooling agent is cold sulphuric acid; in gas coolers where cooling water is sprayed directly through the gas; in air conditioning where air is cooled and dehumidified in spray washers; and in the cooling of non-condensible gases in jet condensers. Cases of indirect transfer from gases to liquids are numerous, occurring in tubestills, economizers, boilers and waste-heat boilers, and direct-fired process vessels. For good transfer it is desirable to achieve a high flame temperature by burning fuel at a rapid rate in contact with radiant surfaces. Owing to the limited vessel area usually available for heat transfer, direct fired applications of this type are likely to be rather inefficient from a fuel standpoint, in the order of 20–30 percent efficiency. Thus, flue gas temperatures will be high, about 1,000 to 1,200 deg. F. if the product temperature is 600 deg. F., as compared with efficiencies in the order of 75 percent for standard industrial steam boilers and boiler flue temperatures of 500–600 deg.F.

11. Gas to Boiling Liquid—The heat transfer principles in this group are similar to those of Case 10, except for the more favorable film coefficient of the boiling liquid side. This condition is often encountered in the same apparatus as in Case 10, either at a later time, or at a point in the apparatus farther along the liquid flow path. Owing to the fact that the gas side convection resistance is proportionately a more serious limiting factor in this case, the use of extended surface on the gas side is often practical. For example, in waste-heat boilers the tubes are sometimes provided with cast iron fins on the gas side.

12. Gas to Gas—Since gases mix completely with other gases in all proportions, the only usual direct examples of Case 12 are found in instances where it is desired to heat a gas by injecting a hot gas, or to cool a gas by injecting a cold gas. The latter might be for the purpose of avoiding damage to a product or to equipment, or for the improvement of heat transfer by the recirculation of combustion gases. With a good degree of turbulence there is no serious heat transfer problem in direct applications. A common example is found in the case of recirculation type dryers in which flue gases are recirculated and mixed with the hot combustion gases, thus lowering the gas temperature before it comes in contact with the product. Instead of recirculated flue gases, fresh air may be used. A similar scheme is sometimes used to avoid damage to equipment. For example, it may be desired to draw flue gas through a fan after it leaves the process at an elevated temperature. The expense of a special high temperature fan can be avoided by lowering the gas temperature by the admission of fresh air to the fan.

In the case of indirect transfer from gas to gas, unfavorable transfer conditions exist on both sides of the intervening wall and in some cases extended surface may be used on both sides. Examples exist in the case of air preheaters and other recuperators, steam superheaters, gas-gas heat exchangers and in pipestills at points where vaporization has already taken place. The difficulty of calculating heat exchange of this type is exemplified in steam superheaters where the exact results cannot be predicted and a correction is made after the boiler goes into operation by adding or removing sections of superheater surface.

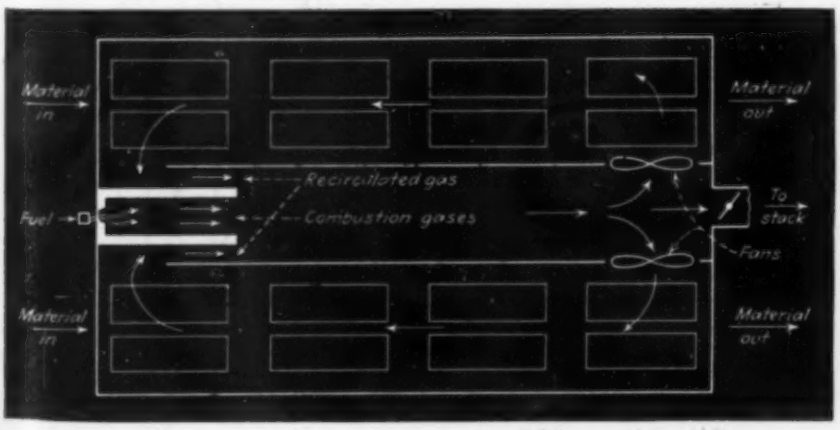
13. Condensing Vapor to Solid—The presence of a condensing vapor on one side of a heat transfer surface introduces a new factor not previously mentioned in this discussion, namely, the fact that condensation may occur in two different ways, either as a continuous film or in the form of separate droplets. Ordinarily, film condensation takes place, but much higher transfer rates are possible if drop-wise condensation can be maintained by suitable surface treatment. Nevertheless, film condensation offers a good convection rate as compared with heat transfer from a bulk liquid to a surface. Little, if any, use is made of Case 13 in direct applications. Among indirect applications, where a wall separates the condensing vapor from the solid receiver of the heat, may be mentioned steam tube dryers, steam heated kettles for the melting of solid materials, steam heated trays in vacuum dryers, and similar applications. Cases involving cooling include the use of ice in direct contact with air for dehumidification and the use of solid carbon dioxide in condensing vapors in high vacuum pumping.

14. Condensing Vapor to Liquid—Examples of this type of transfer, where heat passes directly from the condensing vapor to a liquid, occur in steam distillation; in the heating of liquids by the direct injection of steam; in jet and other direct-contact condensers; in steam accumulators; and in the case of the heat transfer that occurs between the bottom product and the overhead product on the trays of a distilling column. In general, heat transfer of this character is rapid and efficient. Indirect applications occur in numerous examples, for instance, in many types of process vessels heated by steam and other vapor media, including kettles, evaporators and stills. Steam heated water heaters, and surface condensers, are also examples of indirect heat transfer.

15. Condensing Vapor to Boiling Liquid—The highest convection transfer rates are obtained in examples of this class since both film coefficients tend to be high. In general, the examples are similar to those of Case 14 including, among direct applications, the heat transfer in distilling columns and in steam distillation; and the use of direct steam for boiling process liquids. Among indirect applications may be mentioned vapor heated stills, kettles and evaporators.

16. Condensing Vapor to Gas—This type of transfer is found mainly in indirect applications in which a wall separates the condensing vapor from the gas. Since the gas side coefficient is poor, good turbulence is necessary and extended surface is frequently used on the gas side. The case is substantially the reverse of Case 11. Examples occur in air cooled condensers; in space heating with steam radiators; in the use of steam reheaters in air conditioning and in other similar applications.

Fig. 9—Recirculating counterflow dryer improves convection by high turbulence and increased opportunity for heat transfer from bulk of gas to solids



SPECIAL MEDIA

For the Transfer of Heat

EDITORIAL STAFF

HEATING and cooling of process materials are often handled more effectively through the use of a heat transfer medium, rather than direct to the source of heat or cold. For this purpose liquids, gases, condensing vapors, boiling liquids, and even finely divided solids in suspension are all employed, the type used depending on the temperature range as well as on a number of other factors of suitability including safety, ease of operation, corrosiveness, toxicity, and the overall cost of production. In the last named consideration must be taken of both capital costs and operating costs. Use of a medium generally complicates the overall process as compared with direct heat transfer, and may reduce the possible thermal efficiency owing to the multiplication of heat exchanges which it requires. On the other hand, numerous advantages in improved controllability and more flexible use of heat or cold sources generally more than offset the disadvantages.

No media are available for use in the highest temperature range, other than gases, which can be used in all temperature ranges. Below this, molten salts and salt mixtures, and molten metals can be used while temperatures from about 1,000 deg. F. down to atmospheric can be handled with a number of available condensing vapors, or the corresponding liquids, including mercury, Dowtherm and water vapor, in decreasing order of temperature. Many other liquids are also used, the choice generally depending first on the temperature of use. These include molten organic solids, oils, organic liquids, solutions of organic liquids in water, and water solutions of inorganic salts.

In what follows space is not available to discuss all media that are used, even in the process field, while those employed for other purposes, such as in metal working, heat treatment and as engine coolants can be mentioned only in passing.

Gaseous Media—Owing to their low heat capacity and their poor characteristics from a convection standpoint, gases are not good heat transfer media although there are many instances where another type of medium is impracticable. In dryers, for example, gases are able to do double duty, acting both as heat and as moisture carriers. Air and flue gases are the most common gaseous media, since they are readily available, at no cost. Other gases may be preferable however under special circumstances, for example, when a gas of high specific heat and low windage loss, such as hydrogen, is chosen for use in the cooling of electric generators; or when a reducing medium such as natural gas is required, as in the Hansgirg magnesium process.

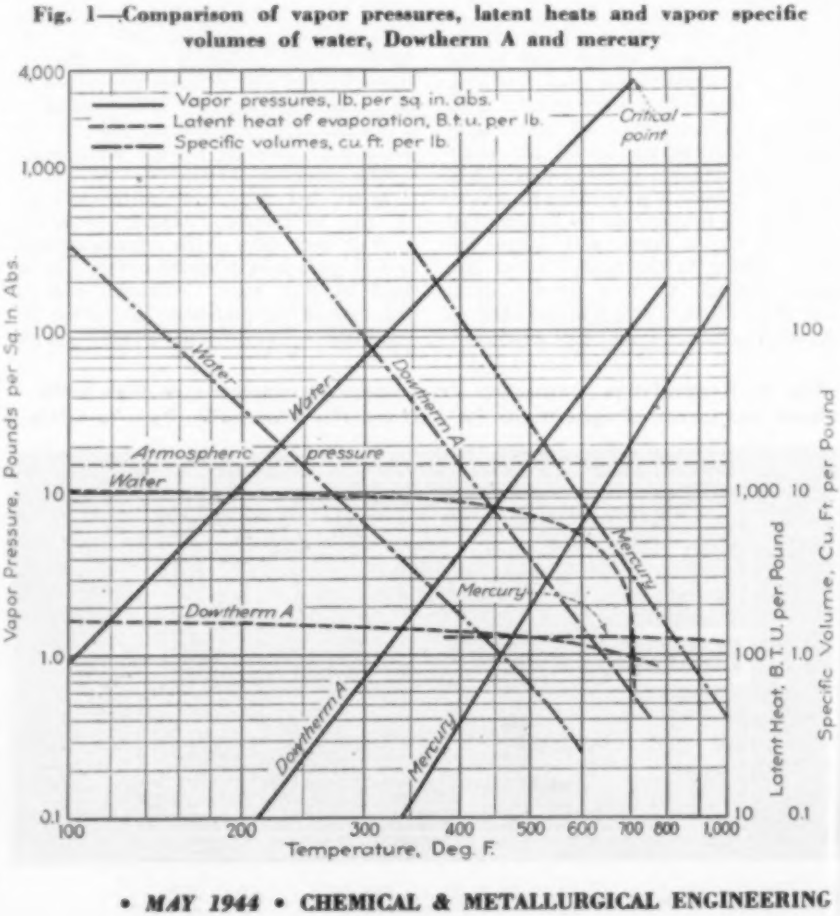
Liquid Media—In general, any saturated vapor is preferable to the corresponding liquid for heating, since its pressure is no higher, it requires no pumping on the hot side, and in simple systems may not require pumping even on the condensate return side. Finally, and most important, vapors are able to give up a large amount of heat in condensing at constant temperature and pressure, whereas liquids must drop in temperature as they give up heat, and many more pounds of liquid must be handled for the same quantity of heat transferred. Condensing vapors also have much larger heat transfer coefficients.

With the one exception of having a high vapor pressure at high temperatures (see Fig. 1), water is the ideal liquid transfer medium for use from slightly above freezing to, say, 400 or 450 deg. F. It has a high specific heat, density and thermal conductivity, and a low viscosity in comparison with most other materials that might be used. Its availability, negligible cost and relative freedom from corrosion in confined systems are also important considerations. However, water is rather infrequently used as a heating medium in industrial practice, mainly because of the advantages of steam. It's principal field is in cooling.

Other liquid media are sometimes used for higher temperatures. A petroleum oil fraction has been used quite extensively at atmospheric pressure for the temperature range from around 300 to about 550 deg. F., with a theoretical limit of about 600 deg. In recent years this method has to a large extent yielded to the use of Dowtherm, usually in vapor form. Dowtherm itself (ordinarily used as the eutectic mixture of 73.5 percent diphenyl oxide and 26.5 percent diphenyl and known as Dowtherm A) is sometimes used as liquid at temperatures below its boiling point. The material melts at 56.3 deg. F., and boils at atmospheric pressure at 500 deg. F., therefore being usable as a liquid up to a temperature corresponding to a saturated steam pressure of 681 lb. abs. It can of course be used at higher pressures than atmospheric as a liquid, but this is ordinarily done only for cooling. A system sometimes employed for Dowtherm liquid heating at temperatures above its atmospheric boiling point makes use of saturated vapor for heating circulating Dowtherm liquid, by direct contact in a simple ejector heater. In batch processes, where cooling may be required after heating, cooled Dowtherm liquid may be used, as indicated in the right hand portion of Fig. 2. For cooling valves (2) are opened and valves (1) are closed.

Mercury, a suitable vapor transfer medium for the temperature range above Dowtherm, is not used in liquid form except for the occasional cooling of high temperature exothermic organic reactions, in which case it is allowed to boil, thus extracting heat as latent heat of vaporization.

Fig. 1—Comparison of vapor pressures, latent heats and vapor specific volumes of water, Dowtherm A and mercury



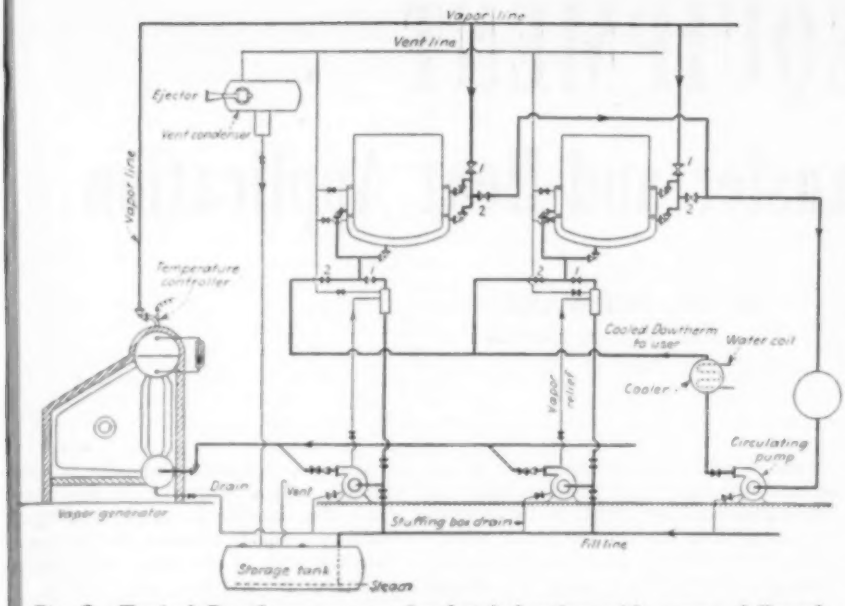


Fig. 2—Typical Dowtherm system for batch heating with vapor, followed by cooling with Dowtherm liquid

At temperatures above the 700 deg. F. limit for Dowtherm vapor (decomposition begins at 750 deg.) the tendency at present is to employ molten inorganic salt mixtures, of which the best known is H.T.S. This mixture contains approximately 40 percent of $NaNO_2$, 7 percent $NaNO_3$, and 53 percent KNO_3, by weight. According to Kirst *et al* (*Trans.* A.I.Ch.E., May 1940) the mixture freezes at 288 deg. F. and can be used at temperatures in excess of 1,000 deg. F. It has found extensive employment in the Houdry catalytic refining process and in other applications.*

Molten metals also have been used to some extent as heat transfer liquids, mainly, however, in heat treating. Lead, melting at 327.5 deg. C., and boiling at 1,620 deg. C. is the commonest of these, and has been used to a small extent in high temperature reactions, such as in the pilot plant operation for one of the butadiene processes. Except for its high cost and scarcity, tin has been suggested as a particularly suitable metal for this purpose, since it melts at 232 deg. C. and boils at 2,260 deg. C., giving an exceptionally wide range of use. Metallic sodium and several low melting alloys have been proposed for heat transfer use, but it is believed that they have been used only occasionally.

Liquid Coolants—This article is of too limited scope to discuss the liquid coolants, rather than to mention some of the materials that are used in this fashion. Water is the best coolant within its range of usable temperatures and water solutions are commonly used where temperatures below its freezing point are required. Ethanol, methanol, the ethylene glycols, glycerol, and glucose are all used where a non-corrosive coolant is required, as for internal combustion engine cooling. As a general rule, although the first four can be employed alone, they are used in as dilute a water solution as will give adequate protection against freezing. Brines, consisting of solutions of inorganic salts such as NaCl and $CaCl_2$ in water, ordinarily find application in the refrigeration range for industrial purposes. Their properties are covered adequately in refrigeration handbooks.

Condensing Vapors—The entire temperature range from that of steam at atmospheric pressure, or even sub-atmospheric pressure, up to 700 deg. F., can be covered in heating applications by the use of the saturated vapors of water or of Dowtherm A. There is also the postwar possibility of employing other saturated organic vapors, such as the Freons, at still higher temperatures. Mercury vapor, despite its cost and present unavailability, has had fairly extensive use in the range from 400 or 500 deg. to about 1,000 deg. F. The chart of Fig. 1 compares several of the properties of water, Dowtherm A and mercury. It is evident that, so far as the properties shown is concerned, water is superior to either of the other media within the range of suitable pressures.

There is no need to discuss the use of steam as a heating medium, other than to point out its usual unsuitability for pressures in excess of about 450 lb. ga., corresponding to a saturation temperature of 460 deg. F. Occasional use has been made of higher pressures for heating, (rather than power), but the curve of pressure ascends rapidly and even a pressure of 1,500 lb. corresponds to a temperature of slightly less than 600 deg. F. Occasional application is also made of more than nominal superheat, but superheated steam possesses the usual disadvantages of hot gases for heat transfer, and superheat is used ordinarily only in sufficient amount to insure the delivery of dry steam at the point of use. The principal exception is in steam distillation.

Dowtherm A has progressed rapidly as a vapor heat transfer medium for temperatures from 400 to 700 deg. Steam at sub-atmospheric pressure is not often employed for heating in industrial processes, but there is some application of Dowtherm in this fashion, since its atmospheric boiling point of 500 deg. F. is somewhat beyond the topmost temperature that is ordinarily attained with steam. More use, however, occurs at temperatures above 500, thus simplifying the condensation and boiler return problem. The handling of hot Dowtherm, both liquid and vapor, has now developed satisfactorily and the production and maintenance of tight systems are not now a problem. Pumping no longer offers difficulties, and pump return to the boiler (vaporizer) is now used as freely as gravity return. A simple hook-up for Dowtherm vapor, for heating a number of vessels at the same pressure, coupled with later cooling by liquid Dowtherm, is indicated in Fig. 2. Valves (1) are opened for heating, and valves (2) for cooling. If desired the vapor may be generated at the highest pressure desired and throttled for condensing at lower temperatures for some of the users. This transfer medium has been used extensively in the synthesis of various organics, in the treatment of oils and fatty acids, in manufacturing resins, fusing high melting organics such as asphalt, and low melting metals and alloys, as well as for numerous other purposes, such as sludge acid recovery.

Mercury vapor, as a heating means, is of less interest than formerly, and probably will not regain the place it once enjoyed in a few high temperature operations. Introduced for heating before the advent of Dowtherm, it was once generally considered an excellent medium for temperatures above the 600 deg. F. top for hot oil. Above this temperature only direct firing, molten metals and molten salts were then available. Mercury has many desirable properties from a heat transfer standpoint aside from its usefulness at high temperature, but cost, toxicity and scarcity, coupled with the present availability of less expensive materials which are apparently equal in high temperature suitability, make its return somewhat unlikely for heating purposes.

Solids—The use of finely divided solids densely suspended in a gas as an extraordinarily effective heat transfer medium has recently become a reality. As a by-product of the successful application of solid catalysts in "fluid" form by the Standard Oil Co. of New Jersey, investigation of this principle by the Standard concern and its licensees has also suggested other possibilities than petroleum cracking. Most of these are still speculative or cannot be discussed for security reasons, but it can be mentioned that solids so suspended partake of properties similar to boiling liquids from a heat transfer standpoint. Heat transfer between the solids and the suspending gas is at such a rapid rate that when combustion of the gas is taking place, no flame appears to be produced, while excess air is apparently not needed for complete combustion. Temperature differences throughout the "boiling" mass have been found to be inappreciable. Either heating or cooling of the fluid mass can also be accomplished in surface type exchangers, in which case film coefficients are obtained on the "fluid" side which are comparable apparently to the coefficients that can be obtained with liquids. Used in this manner the solids can be employed for catalytic purposes, in which case they serve also as heat carriers and stabilizers of the operating temperature. Also, it appears possible that inert solids can be used solely for heat carrying and temperature stabilization, and that reactions of solids with gases, and drying and calcining operations, can be accomplished effectively by this means.

*Somewhat similar mixtures have been used for many years in heat treating of metals. A large number of these were described by Tour (Trans. A.S.S.T., Aug. 1942) who listed various combinations of NaCl, $NaNO_2$, $NaNO_3$, $BaCl_2$, KCl and $BaCl_2$ suitable for temperatures from a minimum of 425 deg. to a maximum of 1,650 deg. F.

EQUIPMENT

For Heat Transfer and Heat Application

M. W. SCHWARZ
Consulting Chemical Engineer
New York, N. Y.

IN THE broadest sense the operation of nearly every piece of chemical equipment involves some form of heat transfer. Considered from a narrower but more practical aspect, rates of heat flow that are significant from an engineering standpoint occur in all the chemical process industries, at many different points in their operations, and in practically every unit operation. This universality explains, in part, the continued interest in heat flow problems in chemical engineering. However, the need for continued research may also be due in part to the lack of means for direct measurement of heat quantities and heat flow. There are no direct-reading instruments for measuring the number of B.t.u. flowing per hour, and the precise and convenient instruments used in measuring, for example, the flow of electric current and of fluids, have no counterparts in the field of heat transfer.

In the range of heat exchange problems encountered in power and refrigeration equipment, a relatively few media such as water, steam, refrigerants, brine, and so on, are capable of meeting the requirements, since they possess desirable thermodynamic and physical properties. In contrast, the process field demands equipment for a great variety of chemical products that are frequently corrosive, viscous, reactive or otherwise difficult to handle. Furthermore, the design problem is complicated in many instances by the absence of adequate data on the properties of the materials handled.

There are various ways in which equipment can be classified from the standpoint of heat transfer, none of which is entirely satisfactory. The method used here is as follows:

Subject	Illustrations
1. Heating and cooling liquids	Figs. 1–41
2. Heating and cooling gases	Figs. 42–53
3. Heating and cooling solids	Figs. 54–63
4. Distillation of liquids	Fig. 64
5. Sublimation of solids	Fig. 65
6. Evaporation of liquids	Figs. 66–74
7. Drying solids plus liquids	Figs. 75–78
8. Condensation of vapors	Figs. 79–81
9. Fusion of solids	.....
10. Freezing of liquids	Fig. 82

TRANSFER BETWEEN LIQUIDS

Heating and cooling of liquids by means of liquids is the most important phase of heat transfer in the chemical industry and heat exchangers are the outstanding example of equipment in this field. There is no entire agreement on terminology in respect to equipment but the term heat exchanger is usually reserved for liquid-to-liquid units which do not involve condensation or evaporation. There are several ways of classifying the numerous types of exchangers, for example, as horizontal or vertical; and with respect to the tube arrangements in tube-side flow (e.g., single-pass and multi-pass), and shell-side flow (e.g., single-pass and multi-pass). The shell-side flow may be parallel or counter to the flow in the tubes or it may cross the tubes. The exact arrangement of surfaces includes such variations as shell-and-tube; concentric-tube or double-pipe; spiral-plate; and flat-plate-heat exchangers.

Before describing individual pieces of equipment it should be noted that the illustrations in this article are largely diagrammatic, intended to emphasize principles rather than actual design.

The simplest and usually the least expensive form of shell-and-tube heat exchanger is shown in Fig. 1. This type is constructed with the tubes attached to fixed heads or tube sheets. The liquid on the tube side is constrained to flow through the tubes. In order to constrain the shell-side liquid similarly and at the same time to insure maximum turbulence with the least possible pressure drop consistent with good turbulence, various types of baffles are installed in the shell. Fig. 2 diagrams several baffle arrangements.

The segmental type at a is most generally used. Sieder (*Chem. & Met.*, 322–25 1939) states that orifice type baffles are not intended for use with fluids of a fouling nature, nor for use with corrosive fluids. For most services he recommends the disk and doughnut type.

When there is no great difference in temperature between the tube-side and shell-side liquids, no special provisions are needed to minimize expansion stresses between the tube and the shell. However, many applications require such provisions. There are several ways of taking care of this expansion, including methods of building longitudinal flexibility into the shell, and methods of leaving one end of the tube bundle free to expand or contract. Fig. 3 shows three methods of introducing flexibility into the shell. Fig. 4 portrays the common method of avoiding expansion stresses, through the use of U-tube or hairpin tube elements. This method is one of the least expensive and permits rea cleaning of the shell side of the tub since the bundle is easily withdra Ordinary methods, however, do not perm ready cleaning of the tubes with smal radius bends.

The most common method of tak care of differential expansion is with floating head. Some types permit rea removal of the tube bundle for clean the shell side, while with others the bund cannot be removed without cutting out t tubes and hence can be used only service with non-fouling liquids on t shell side. Figs. 5 to 7 show seve designs. That in Fig. 5 is a free-floati head, designed to permit withdrawing t tube sheet through the shell. The floati head cover is held on by means of bo and a split ring, or by cll bolts (Vog Figs. 6 and 7 show packed floating he That of Fig. 6 is an inside packed des while that of Fig. 7 is outside packed, viating any possibility of leakage betwe the shell- and tube-side liquids. In of these types a removable cover can provided to permit cleaning the tu without disconnecting piping.

According to W. L. Nelson ("Pe leum Refinery Engineering," 2nd E McGraw-Hill, 1941), tubular equipm gives heat transfer rates that are usu about twice as great as those obtained coil-in-box equipment. However, tub equipment is not generally recommen if the cooling water is extremely hard dirty, or if there are severe corrosive co tions. It is the consensus of opinion am manufacturers of heat exchangers t not over two, or at most, four passe liquid through the shell side of an changer should be used, and that no m than six multi-passes on the tube s should be employed.

Aside from the fact that they tend complicate piping, single-pass exchan have the disadvantage that several s units may cost considerably more t the equivalent heat transfer area in a larger shells with several passes. Thi especially true where only a relatively s amount of heat transfer is involved. Sin pass exchangers have the advantages of ing true countercurrent flow; of permitt ready cleaning and repair, inasmuch as unit at a time can be removed from system without serious interruption operation; of easier handling and clean owing to lesser weight; and of easier

stallation, aside from the multiplicity of connections necessary. Fig. 8 illustrates a "2–4" exchanger comprising two well-baffled shell passes and four tube passes. The same effect may be obtained by ganging exchangers as shown in Fig. 9, a common arrangement in the petroleum industry.

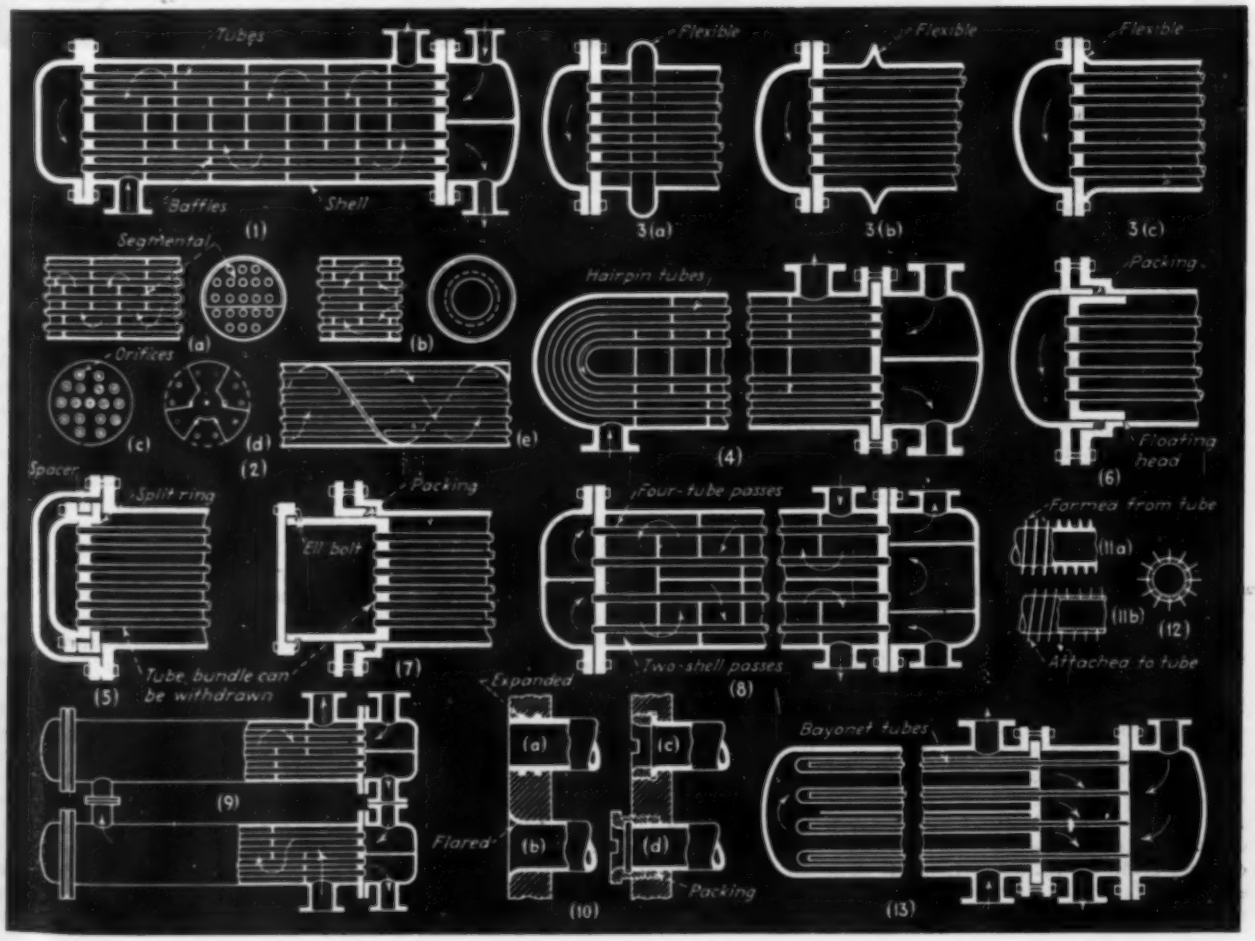
Several methods are in use for attaching tubes to tube sheets in heat exchangers. Some of the most common methods are illustrated in Fig. 10. In cases where frequent re-tubing is not necessary, tubes are generally rolled into the tube sheets. The common method shown at *a* gives a firm attachment by expanding the tube into grooves cut in the tube sheet. The method at *b* shows a flared tube, a more expensive construction sometimes used at the entrance end, with or without grooving. The methods of *c* and *d* show the use of ferrules for removable tubes. Construction *c* employs no packing, while construction *d* makes the tube tight by a stuffing box arrangement which permits longitudinal expansion and contraction.

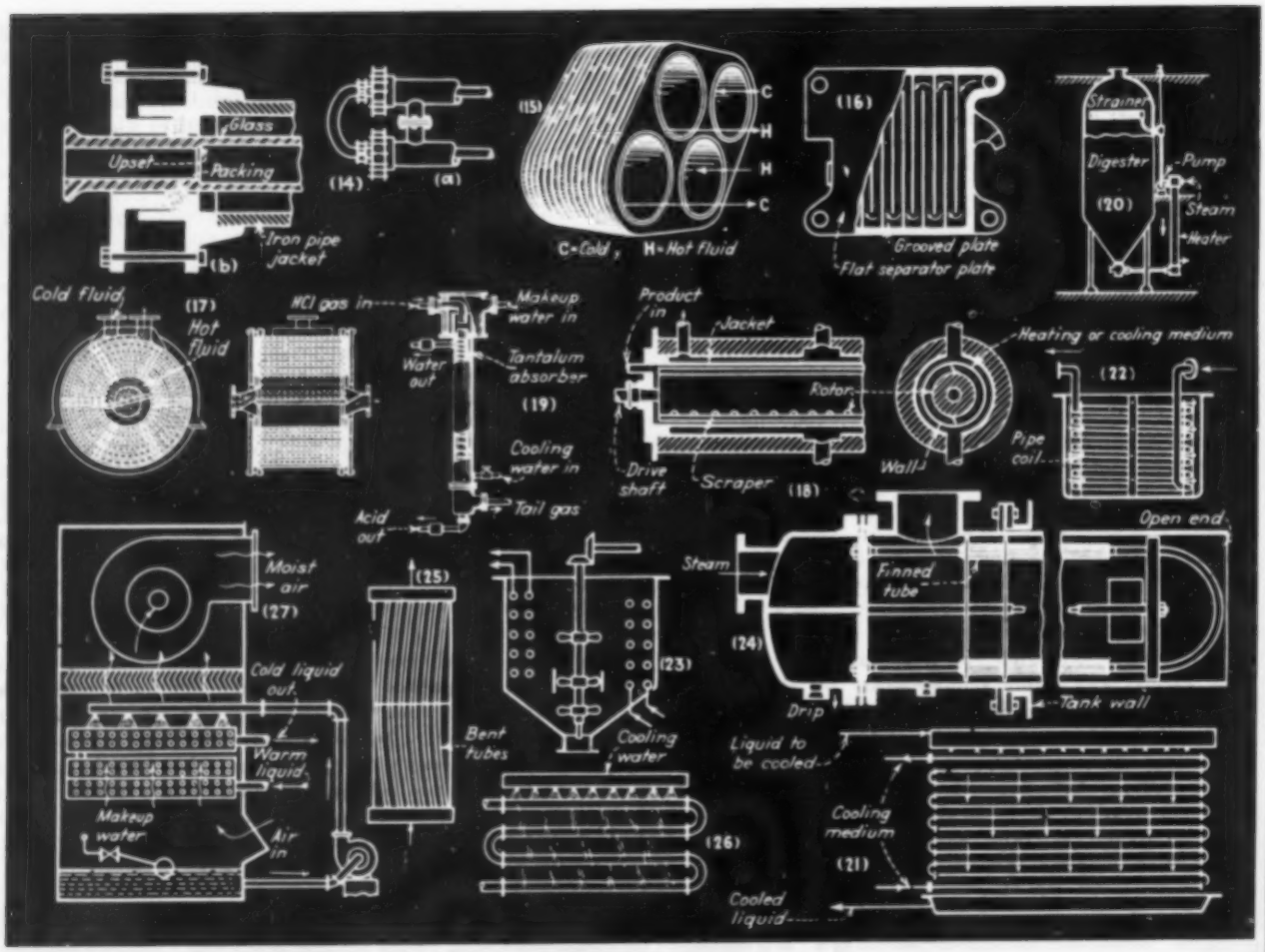
Most generally tubes which are smooth on both the inner and outer surfaces are used in liquid-liquid heat exchangers, but there is nevertheless considerable application of extended or compensated surface tubes in cases where the film resistance of one of the liquids is considerably higher than that of the other. Three types of extended surface tubing used for liquids appear in Figs. 11 and 12. Fig. 11*a* shows Shellfin tubing, a development of the Downingtown Iron Works. In this tubing, which is of the cross-fin type, the fins are produced by extrusion. The claim is made for this type that, having a ratio of about 3½ to 1 for the outside-to-inside area, compared with about 8 to 1 for conventional cross-flow and longitudinal fins, if offers a higher overall transfer rate in the range of applications where bare-tube heat transfer coefficients run from about 250 B.t.u. per hr., sq. ft. and deg. F., down to about 25.

In Fig. 11*b* is shown the type of cross-fin which is produced by brazing or soldering a helical strip in a groove cut in the outer wall of the tube. Good attachment is essential to avoid defeating the purpose of the fin. The same principle is embodied in the radial-type fin (Griscom-Russell G fin) shown in Fig. 12. The helical type is used for cross-flow, while the radial type is intended for shell-side flow parallel to the tube.

Some of the less usual types of liquid-liquid exchangers are shown in Figs. 13 to 19. The exchanger of Fig. 13 illustrates the employment of bayonet type tubes which, despite the fact that they are readily cleanable, are ordinarily used only for non-fouling liquids (or for steam) in the tubes. Fig. 14 illustrates the general class of concentric or double-pipe heat exchangers which are generally used for low rates of flow in place of shell-and-tube exchangers. The particular application of this type illustrated is a Corning design employing a Pyrex glass inner tube running through a steel outer tube, for applications where a process liquid must be handled in glass. Fig. 14*a* illustrates the stuffing box arrangement, while Fig. 14*b* illustrates the

(1) Simple shell-and-tube heat exchanger with fixed tube sheets; (2) Baffle arrangements for shell-and-tube heat exchangers including, at *a*, segmental type; at *b*, disk and doughnut type; at *c*, orifice type; at *d*, vane type; and at *e*, spiral type; (3) Various arrangements for handling shell expansion including at *a*, flexible shell corrugation; at *b*, flexible flanges in shell; at *c*, flexible flange at tube sheet; (4) U-tube (hairpin tube) shell-and-tube exchanger; (5) Free floating head of withdrawable type; (6) Inside packed floating head; (7) Outside packed floating head; (8) Exchanger with two shell and four tube passes; (9) Two exchangers ganged to produce two shell passes and four tube passes; (10) Various methods of securing tubes in tube sheets; (11) Cross-finned tubing, including, at *a*, extruded type; and at *b*, attached fin type, both for liquids; (12) Radial fin tubing; (13) Bayonet type tubes in a shell-and-tube exchanger





(14) Details of double-pipe exchanger with Pyrex inner tube; (15) Section of Griscom-Russell Tubeflo tubing; (16) Plate of Walker-Wallace A.P.V. plate-type exchanger; (17) Two views of American Heat Reclaiming spiral heat exchanger; (18) Votator exchanger for viscous materials; (19) Section of Fansteel tantalum absorber for HCl; (20) Application of external heat exchanger for heating digester contents; (21) Baudelot cooler; (22) Coil in acid cooler; (23) Coil-cooled agitated crystallizer; (24) Griscom-Russell tank heater equipped with radial-finned U-tubes; (25) Griscom-Russell Bentube section; (26) Trombone cooler for liquids (and gases); (27) Niagara Blower evaporative cooler for process liquids

assembly of two units coupled with a return bend of glass. In double-pipe exchangers the inner and outer pipes may both be constructed of metal if desired, and for special applications the inner pipe is sometimes of non-metallics other than glass.

A novel type of heat exchange tube, particularly for applications at high temperature and pressure and for use with dirty liquids, is the Griscom-Russell Tubeflo section illustrated in Fig. 15. In this type four tubes, two for the hot liquid and two for the cold liquid, are expanded into metal plates which serve both as reinforcement and as paths for heat flow between the various tubes. Fig. 16 illustrates one plate and a separator of the Walker-Wallace A.P.V. plate-type exchanger. Several of these plates are assembled in a frame equipped with a movable head and hand-screw, like a filter press. Such an exchanger is readily disassembled for cleaning. Another novel exchanger, the spiral type produced by American Heat Reclaiming Corp., is shown in Fig. 17. This design provides a large amount of heat exchange surface in a comparatively small volume, requiring about one-third the floor area and occupied space of a conventional heat exchanger. Since there are no baffles, it is claimed that all of the pressure drop through the exchanger creates desirable velocity and turbulence. Such exchangers have been more widely employed in Europe than in the United States, finding use in pulp and sugar mills, refiners, etc.

An unusual type of heat exchanger developed originally for the cooling of viscous materials and semi-pastes is the Girdler Votator, shown diagrammatically in Fig. 18. This design employs a jacketed tube, within which is a solid cylindrical rotor concentric with the tube, and large enough to leave only a small annular space between the rotor and the tube wall. The cooling (or heating) medium flows through the jacket, while the liquor to be cooled passes between the tube wall and the rotor. Scrapers mounted on the rotor assure the maximum degree of turbulence consistent with the viscosity of the material. Still another unusual type is the tantalum-shell heat exchange surface which is built into the HCl absorbers manufactured by Fansteel Metallurgical Corp., and typified by Fig. 19. The tantalum shell contains acid-proof packing and is surrounded by a water jacket to remove the heat of absorption when HCl gas is dissolved. The absorber is very compact in comparison with designs of other materials resistant to HCl, owing to the high rate of heat transfer obtained.

One novel arrangement that is being applied to shell-and-tube exchangers of an otherwise conventional type is the cleaning device for the outside of the tubes developed by Davis Engineering Corp. This design provides movable baffles which can be operated from outside the shell to scrape the outside of the tubes. It has been employed in preheating heavy petroleum products as well as white water, in paperboard manufacture.

Frequently heat exchangers are used in conjunction with equipment which does not lend itself readily to the use of integral heat transfer surfaces. In this case an external heat exchanger, circulating the heated or cooled liquid to the equipment, can readily be used. A typical example of such an external heat exchanger is shown in Fig. 20, for heating the contents of a pulp digester. The particular application

wn is that developed by Fiber Making ocesses, Inc.

TUBES AND COILS

The heat exchangers so far discussed e all been characterized by the fact that th liquids were constrained to follow re or less definite paths. On this ac- nt, in these types a degree of control n be had over the film coefficients on th sides of the heat exchange surface. a wide class of equipment employing es and coils the liquid outside is not strained to follow a definite path. In- ded in this group are a variety of ar- gements in which a liquid (or some- es a gas) flows within a straight or led tube while the heating or cooling dium surrounds the tube or flows over it gravity.

In Figs. 21 to 28 are shown a group of t exchange applications of this type. e Baudelot cooler of Fig. 21 is often d for cooling liquid products in the d industry, as well as for water cooling refrigeration processes. It frequently ploys direct expansion of the refriger- in the coils. Fig. 22 illustrates the in- ensive but also relatively inefficient coil- ank arrangement often used for cooling ds or for heating or cooling the con- tents of kettles and tanks. The efficiency can be improved considerably by the addition of an agitator. A case where agitation is employed is in the open-tank batch crystallizer of the coil-cooled variety illustrated in Fig. 23.

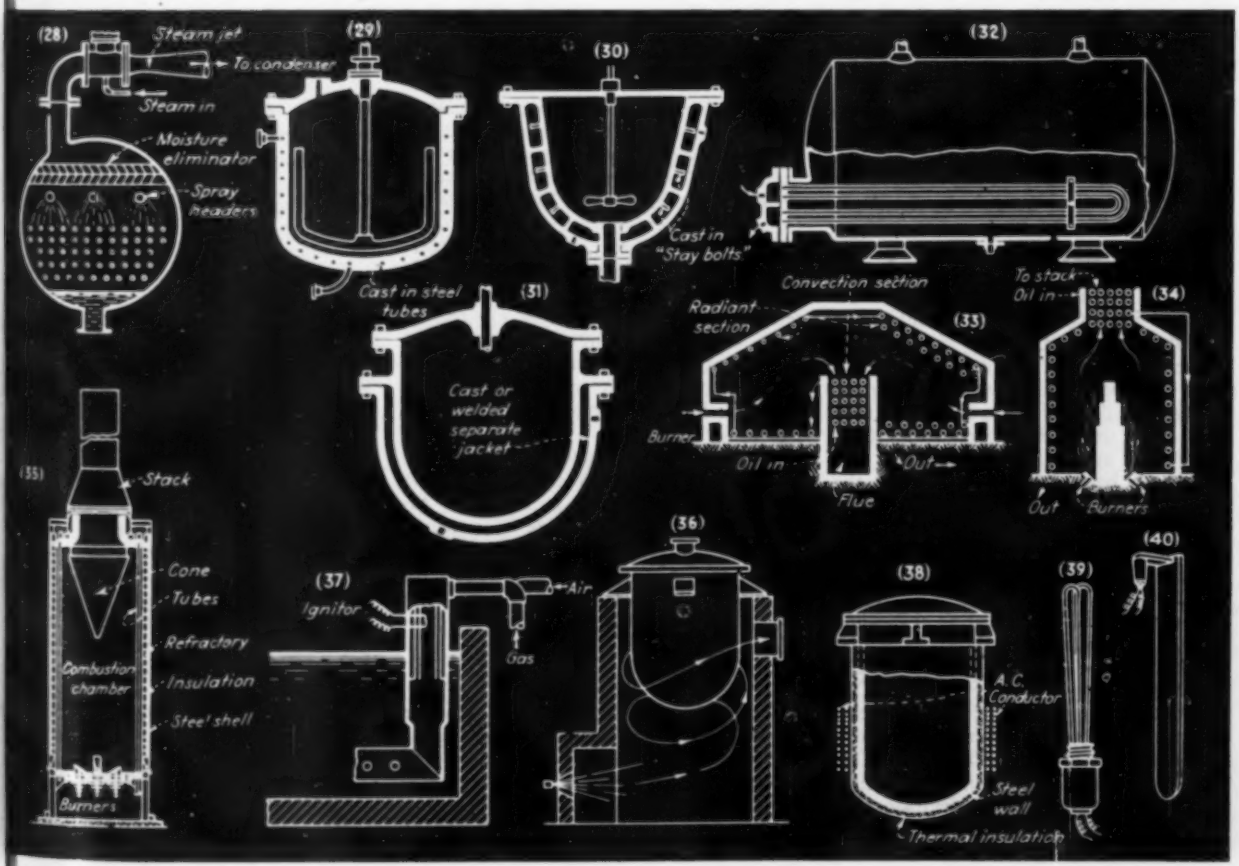
Fig. 24 shows a type of tank heater which has come into use extensively for the heating of viscous liquids such as petroleum prior to pumping. One shell end is open and the shell is attached to the tank wall. This arrangement allows the tank contents to be heated locally, with a considerable saving in time and heat. The heating element shown is of the U-tube type, equipped with radial fins designed to overcome the high film resistance of a viscous liquid.

Submersion type coolers with straight or bowed tubes are used to a considerable extent, for example in the petroleum industry, particularly where only poor water is available for cooling. The Griscom-Russell Bentube section illustrated in Fig. 25 is such a submerged cooler. It will be noted that the tubes are bent between the headers, and that the rigid framework causes changes in tube curvature to take place with changes in tube temperature. This action cracks off the scale, largely eliminating hand cleaning. In addition to operating submerged, such coolers are often installed beneath the packing of cooling towers. Fig. 26 shows a trombone cooler, consisting of a number of lengths of water-sprayed or air-cooled pipe, of metal or ceramic material, in which liquids or gases are frequently cooled, for example, sulphuric and other acids.

A combination of liquid cooling of materials in tubes, with evaporative cooling of the cooling liquid itself, is illustrated in Figs. 27 and 28. In evaporative coolers, such as that diagrammed in Fig. 27, the water-sprayed surface is comparable to the packing in a cooling tower, presenting a large evaporative surface to the flow of air passing through the device. Most of the heat is extracted from the cooling coil by evaporation, rather than by transfer of sensible heat to the air. A similar effect which, however, is capable of yielding much lower temperatures, is found in vacuum coolers of the type illustrated in Fig. 28. The temperature of the coolant in atmospheric evaporation can not be lower than the air dewpoint, whereas, in vacuum evaporation, the coolant temperature is the boiling point under the existing vacuum.

Several representative types of process vessels provided with jackets of various types for heating or cooling are illustrated

(28) Liquid cooling tubes installed in a jet vacuum ooler; (29) Frederking kettle construction; (30) Dopp ettle construction; (31) Typical castiron jacketed ket- le; (32) Storage type water heater with hairpin heating oil; (33) Central convection type tubestill furnace; (34) Double upshot type pipestill furnace; (35) Petro-Chem vertical radiant Iso-Flow furnace; (36) Direct-fired process vessel; (37) Submerged Combustion Co.'s burner; (38) Induction-heated process kettle; (39) General Electric immersion resistance heater for water; (40) General Electric immersion heater with lead sheath for use in dilute acids



in Figs. 29 to 31. The Frederking construction of Fig. 29 consists of a steel coil embedded in a cast iron kettle wall, for high temperature water or steam. In the case of the Dopp kettle construction, one version of which is shown in Fig. 30, the body and jacket of the kettle are cast in one piece with cast-in reinforcements between the jacket and kettle surfaces. Kettles of the type of Fig. 31 may be constructed of either cast iron, with a cast iron or welded steel jacket, or of welded steel, with a welded steel jacket. Another type of heating application with the liquid unconfined on one side of the transfer surface is the storage type water heater illustrated in Fig. 32.

GAS HEATING

In many applications liquids are heated by gas convection and by radiation in direct-fired furnaces. A number of arrangements of pipestills and tubestills are illustrated in Figs. 33 to 35. W. L. Nelson ("Petroleum Refinery Engineering," 2nd Ed., McGraw-Hill, 1941) points out, referring to designs of the types of Figs. 33 and 34, that a large part of the heat is transmitted to the coils by radiation, and absorption rates of 45,000 B.t.u. per sq. ft. of projected area have been obtained commercially. Control of heat distribution is obtained by using a number of small burners on either side of the central bridge wall, and also by varying the exposure of the flames from the burner firing tunnels. An extremely compact design, the Iso-Flow furnace of Petro-Chem Development Co., appears in Fig. 35. Directionally controlled burners are installed in the floor of the furnace. Vertical heating elements are placed around the entire periphery of the cylindrical combustion chamber. A central re-radiating cone is located at the upper end of the combustion chamber, serving the dual purpose of affording even distribution of radiant heat, and of increasing the flue gas velocity as its temperature is decreased. This furnace is also built in a combination radiation and convection type.

Another application involving direct firing of liquid-heating equipment is illustrated in Fig. 36. Kettles and autoclaves are sometimes direct-fired for processing at temperatures above 300 deg. F.

An extremely efficient method of transferring heat direct from a gas flame to a liquid is the use of submerged combustion, where the products of combustion are discharged beneath the surface of the material being heated. This method offers a thermal efficiency as high as 90 percent, with the advantages of compactness and low first cost. Aside from evaporating, which is discussed later, the method has been used chiefly in the heating of pickling baths. A schematic sketch of the burner made by the Submerged Combustion Co. of America appears in Fig. 37. This equipment has automatic push button starting and temperature control. Available capacities range from 250,000 to 8,000,000 B.t.u. per hour. The gas immersion-tube heater bears a superficial resemblance to the submerged combustion heater, but is more nearly related to indirect heating through a vessel wall. Heat is transferred by convection and radiation from the hot gas to the surrounding metal tube which is submerged in a liquid (or in some cases lines the walls of a furnace for the heating of solids). Applications include the heating of palm oil baths used in the production of tin plate, and the fusion of metals and alloys of low melting point.

ELECTRIC HEATING

A few of the methods for the electrical heating of liquids are illustrated in Figs. 38 to 40. Inductive electric heating, as in Fig. 38, generally employs 60-cycle (or sometimes 25-cycle) current at 110 volts for small applications, at 220 volts for medium applications, and 440 volts for large units. According to Center, (*Chem. & Met.*, 579–82, 1934) and Daniels (*Chem. & Met.*, 325–8, 1935) this method of heat transfer is generally applicable to vessels of any size, shape or wall thickness and is automatically self-protecting since the hysteretic and eddy current phenomena cease near the critical temperature of 800 deg.C. Induction heating can be used where fabricated resistance units are unsuited, assuring uniform heating with absence of hot spots. The method is limited to construction materials such as iron, steel and nickel, except in the metal melting field.

Many types of resistance units are used in process heating. Figs. 39 and 40 are typical. The G.E. Calrod immersion unit for water heating shown in Fig. 39 consists of a nickel-chromium alloy wire resistor in a casing of a suitable metal or alloy which is filled with magnesium oxide powder. The unit is reduced in diameter by the application of high pressure, converting the powder to a solid filling of low electrical and high heat conducting qualities. In Fig. 40 is a unit encased in lead for the heating of dilute acid solutions.

Use of evaporative refrigeration for the cooling of liquids has already been mentioned in connection with Figs. 27 and 28. Compression refrigeration equipment also requires heat transfer surfaces for imparting refrigerating effect to liquids being cooled. The boiling or evaporating liquid refrigerant can be allowed to vaporize in pipe coils, refrigerant evaporators and equipment of the shell-and-tube type, such as the flooded Freon cooler illustrated in Fig. 41. In this equipment boiling of the Freon liquid in the lower shell extracts heat from cooling water or brine. The incoming warm Freon liquid from the condenser is sub-cooled in the small exchanger above the main shell by exchange with the cold Freon vapor. Double-pipe coolers of the flooded refrigerant type are sometimes used in the food field for cooling foods and beverages.

HEATING AND COOLING GASES

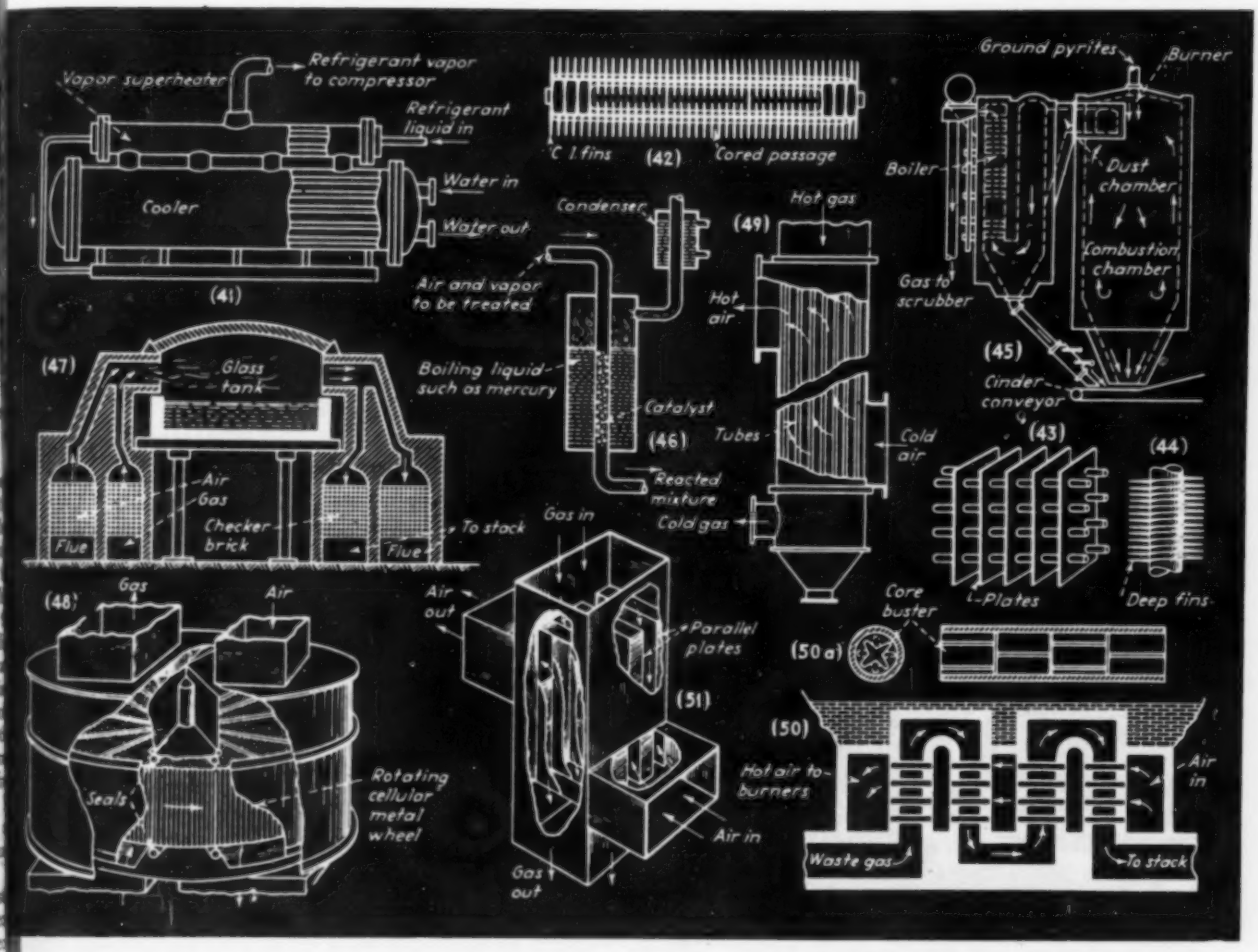
Owing to the fact that heat exchange between gases and liquids involves a poor film coefficient on the gas side, equipment for heating and cooling gases generally requires extended surface. Fig. 42 illustrates a cast-iron finned unit for heating gases by means of steam. The film coefficient for a condensing vapor (as for liqui
is much higher than that for a gas. V
ants of the extended surface principle
clude the types shown in Figs. 43 and
The first consists of a nest of tubes p
ing through and bonded to perfor
plates serving as fins, while the second
cross-finned tube of the helical type, s
lar to the liquid tube of Fig. 11*b*, ex
for having a larger fin area and closer
spacing.

Gases may be cooled by liquids with
direct contact in extended-surface t
of the types previously described, as
as in pipe coils submerged in water.
the other hand, direct contact cooling
spray washers has occasionally been
ployed, using liquid cooling media, a
phosphoric acid manufacture.

One method of cooling gases is to
them through a waste heat boiler for
production of steam. A successful in
trial process in this category is the Nich
Freeman flash roasting system for
burning of pyrites concentrates, as i
trated in Fig. 45. Another example of
cooling of gases by means of a boi
liquid is shown in Fig. 46 which illustr
a gas-phase reactor cooled and maint
at a constant temperature by means
jacket in which mercury or some
liquid is boiling. A reflux conde
cooled by water or air, abstracts heat f
the medium. This type of cooling
been employed, for example, in the
dation of naphthalene for phthalic
dride production.

In many processes involving combus
it is necessary to use regeneration or re
eration to preheat the air in order to s
high enough furnace temperatures,
recover waste heat in the exit gase
improve overall economy. In regener
(Figs. 47 and 48), the heat of the
going gases is stored in a material su
refractory checkerwork or in metal,
to be given up to another cold gas st
in recuperation (Figs. 49 to 51), th
change is continuous from the hot g
the cool gas, through an intervening
or tubular surface. Fig. 47 shows a s
fied cross section of a glass tank an
associated checkerbrick regenerator.
indicated, fuel gas and combustion
enter through the flues at the bottom
passing up through previously heated
work and entering the furnace throug
burner at the left. The hot combu
gases pass downward through the reg
tor brickwork on the right, giving
considerable part of their heat before
ing to the stack. After an interval th
is reversed so that the right-hand re
ators preheat the gas and air while th
hand regenerators are reheated. A
method is used in the blast furnace s
and regenerators of coke ovens,
furnaces and metal melting furnaces.

A checkerbrick regenerator is nece
discontinuous in operation. A conti
type of regenerator is represented i
Ljungstrom air preheater diagramm
Fig. 48. This device consists of a
built up of a large number of metal
presenting through passages for gas
from top to bottom. The rotor is in
within a casing which is divided ac
center line by means of partitions and



(41) Freon-flooded type water cooler; (42) Murray cast-iron finned heating unit; (43) Extended surface unit of tubes inserted through plates; (44) Cross-finned tube for gas cross-flow; (45) Freeman flash roaster, with waste heat boiler; (46) Cooling a reacting gas with boiling liquid; (47) Cross section of glass tank and regenerators; (48) Ljungstrom continuous regenerative air preheater; (49) Tubular type air preheater; (50) Fitch recuperator with carborundum tubes; (50a) Tube with core-busters; (51) Plate-type air preheater

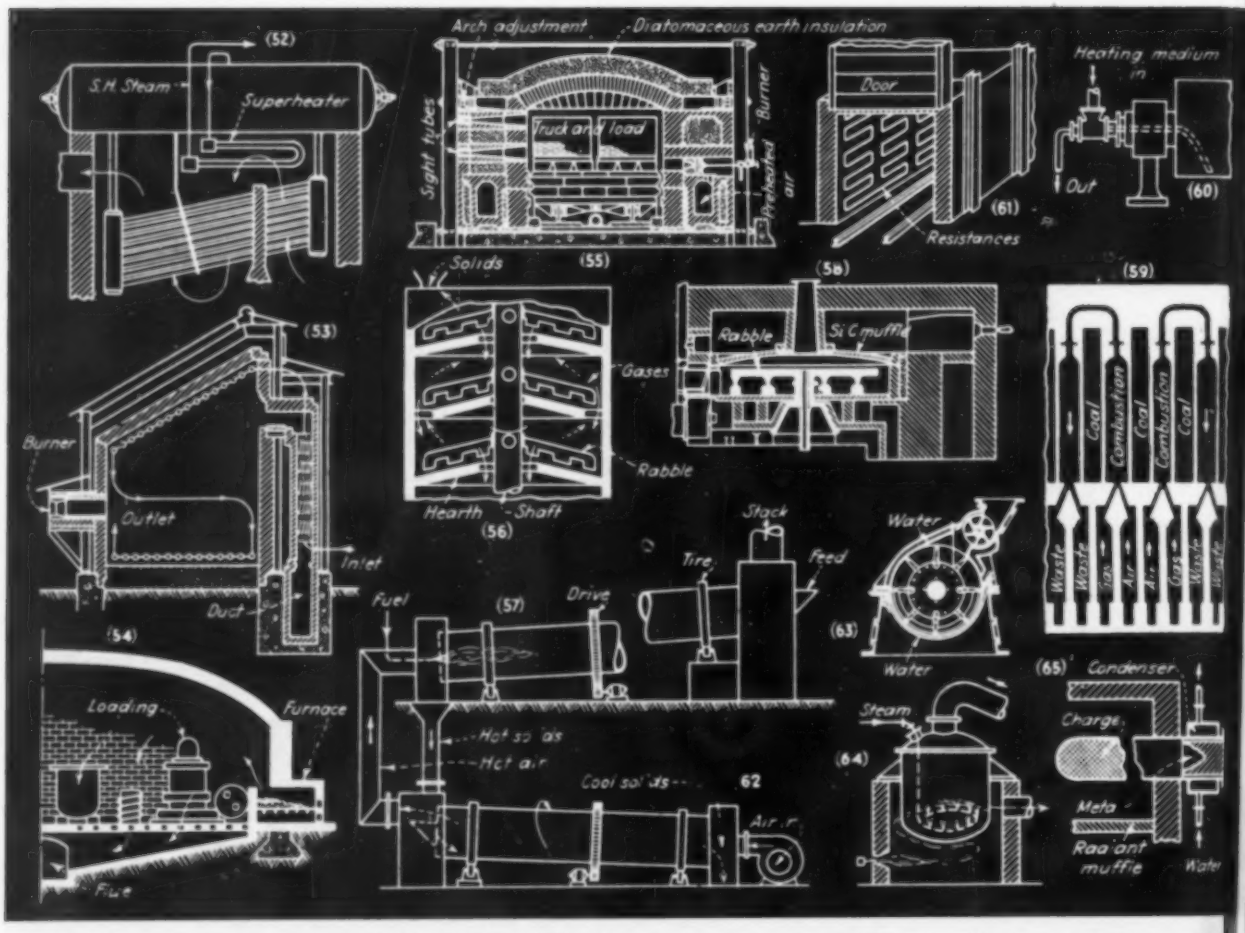
s making separate passages for gas and air. The hot flue gas flows continuly through one side of the drum which, its rotation, carries the stored heat to air side of the partition. Here air flowthrough the heated sections picks up stored heat, and is thus preheated for ubustion. This type of regenerator is remely compact and can transfer large ounts of heat. On the other hand, it uires considerable power for the fans, le air leakage around the rotor is a blem, as is the need for keeping the al surfaces free from soot and corrosion osits, according to Campbell and Kim- (*Nat. Petrol. News*, 33, No. 22, R -172; *Refiner and Natural Gasoline* , 20, 204–8, 1941).

ecuperators are not heat storage de- but are similar to conventional heat sfer equipment. Fig. 49 illustrates a monly used class of air preheater emng tubes as heat transfer surfaces. In design, both the tubes and the shell of metal. On the other hand, large, temperature recuperator installations purposes other than power plants are uently of refractory construction, as rated in the Fitch recuperator design ig. 50. Here the heat transfer elements are carborundum tubes containing core-busters, as illustrated in Fig. 50a, the purpose of which is to create turbulence inside the tubes. Still a third type of recuperator is illustrated in Fig. 51. Here the heat transfer elements consist of parallel, closely spaced plates rather than tubes. Air and gas flow countercurrent in alternate channels.

Superheating of steam is an example of transfer from gas to gas. Steam superheaters of the radiation type are installed in sight of the fire, while those of the convection type, as illustrated in Fig. 52, are installed in the convection passages of the boiler, receiving little, if any, radiant heat. Sometimes separately fired superheaters are used, for example, the Alcorn design of Fig. 53, which is employed for superheating 60 lb. saturated steam to 1,500 deg.F. In this furnace radiation is the dominant factor, as it is in similar designs of oil pipestills, although a considerable down-draft convection section is provided.

HEATING AND COOLING SOLIDS

Solids may be heated by any of the media used for heating gases and liquids, but direct or indirect transfer from combustion gases is, of course, most common. Various types of kilns and furnaces for solids heating are shown in Figs. 54 to 59, and Fig. 61. In all of these the relation between quantities of heat transferred by radiation and by convection depends on the temperature and on the furnace design and disposition of the product. A periodic kiln of the down-draft type extensively used in the ceramic industry for firing heavy clay products is illustrated in Fig. 54. Kilns of this type are relatively wasteful of time, labor and fuel, in comparison with continuous kilns. The design employed in the later classification depends on the form of product. For example, Fig. 55 shows a type for massive solids, while Figs. 56, 57 and 58 deal with pulverized or lump materials. Fig. 55 represents a typical cross section through a direct-fired tunnel kiln for ceramic products, and Fig. 56, a cross section of a multiple-hearth kiln of a sort extensively used in the burning of pyrites fines, in the revivification of filter clays, and in metallurgical roasting operations. Fig. 57 portrays a cement (or lime) kiln, showing the use of preheated air recovered from the clinker cooler, and Fig. 58, a Mannheim furnace which is commonly used for producing salt cake



(52) Convection type superheater in boiler; (53) Alcorn separately fired superheater for 1,500 deg. F. steam; (54) Down-draft periodic kiln for heavy ceramic products; (55) Direct-fired tunnel kiln; (56) Multiple-hearth roaster; (57) Rotary kiln for cement and lime; (58) Mannheim type HCl furnace equipped with carborundum muffle; (59) Cross section of Koppers type coke oven and flues leading to regenerators; (60) Roll with steam and condensate passages through trunnion; (61) Box furnace with wall-mounted electric resistance elements; (62) Air-cooled cement clinker cooler; (63) Raymond water-jacketed pulverizer; (64) Direct-fired steam still; (65) Pidgeon process retort for magnesium metal production

and HCl. The raw materials and products are shielded from the hot combustion gases by a muffle, consisting either of a heavy cast iron pan and cover or, as in the case illustrated, of a refractory hearth and heat-transmitting carborundum arch.

In Fig. 59 in shown a simplified cross section through the retort, combustion spaces and gas passages of a byproduct coke oven. Here the coal is heated in silica brick retorts by means of a preheated gas and air mixture burned in adjacent flues. The combustion gases flow through regenerators (not shown) beneath the ovens, there giving up their heat which is later returned in the incoming fuel gas and air. Through periodic reversals of flow the combustion chambers shown as inactive in the drawing become the active ones.

In Fig. 60 is illustrated the application of a condensing vapor for the heating of solids on rolls or in kneaders. Electric heating, too, is frequently used for solids. In Fig. 61 is illustrated a simple box-type furnace with radiant electric resistance elements mounted on the walls. Arc furnaces are used for solids melting, especially metals, while high frequency dielectric heating is being used increasingly for non-conducting materials. Its applications at present are limited largely to the plywood and plastics molding field but an eventual application is likely in the drying of materials into which it is difficult to transfer heat by ordinary methods.

Most cooling of solids is accomplished by direct contact with a cool gas, or with a liquid. An example of the former is the Sulzer process for the dry quenching of coke in which inert gas is used to transfer heat from the coke to water in a waste heat boiler. Cement coolers are another important application, in this case using the combustion air to recover heat. There are various types of such equipment, ranging from the simple rotating shell illustrated in Fig. 62 to coolers of considerable complexity, designed to insure maximum contact of the clinker with the cooling air.

Use of a circulating liquid cooling medium is common in such kinds of solids handling equipment as rubber rolls, kneaders and grinders. The last type of use, illustrated in Fig. 63, has been applied in certain instances to the grinding of cocoa, zinc stearate, synthetic resins and other products which are injured by the heat produced in grinding, according to Ka witz (*Chem. & Met.*, 236–7, 1938).

DISTILLATION AND SUBLIMATI

Both direct heating and indirect tra by means of hot liquids and conden vapors are used in the supply of heat stills. Condensing vapor is, of cou the commonest source. In addition to plying indirect heat, steam may also introduced directly into the liquid of still pot, a method which is used comm cially in the steam distillation of tur tine, petroleum products, essential glycerine, fatty acids and the stripping light aromatics from wash oil. Steam has the function not only of provid heat, but also of reducing the boiling po through partial-pressure effect. Direct ing of stills is employed to some exten the distillation of nitric acid, fatty acids mercury. Fig. 64 suggests the design direct-fired steam still.

Solids which are to be sublimed ma heated either directly or through the of heat transfer media. Water at l temperature and pressure, oil and D therm are employed under suitable

cumstances, as well as direct firing. Fig. 65 suggests the construction and operation of the retort used for subliming magnesium metal in the Pidgeon ferro-silicon process. Here the briquetted raw materials are heated under vacuum in a chrome-iron retort by radiation from a carborundum muffle. The metal produced by the reaction sublimes, passes a baffle in the retort and condenses in a withdrawable metal tube which is cooled at the outer end of the retort by means of a water jacket.

EVAPORATION

Heat for the evaporation of liquids is supplied in various ways including combustion processes, heat transfer media, and the cooling of the liquid itself. An example of the last case is found in Fig. 66 which illustrates a type of double, horizontal water-cooling tower recently developed by the Marley Co. and said to have the advantage of eliminating recirculation of the moist effluent air. In cooling towers the bulk of the cooling of the water occurs through evaporation and the abstraction of the necessary latent heat from the unevaporated water, rather than from the exchange of sensible heat with the air. The situation is similar to that portrayed in Figs. 27 and 28 and also to that obtaining in spray ponds. A related principle is applied in flash cooling of products by the application of high vacuum to the product and the evaporation of part of its water content. This is used in mash coolers, vacuum crystallizers and in cooling batches in the production of synthetic resins and other substances having low film coefficients of heat transfer.

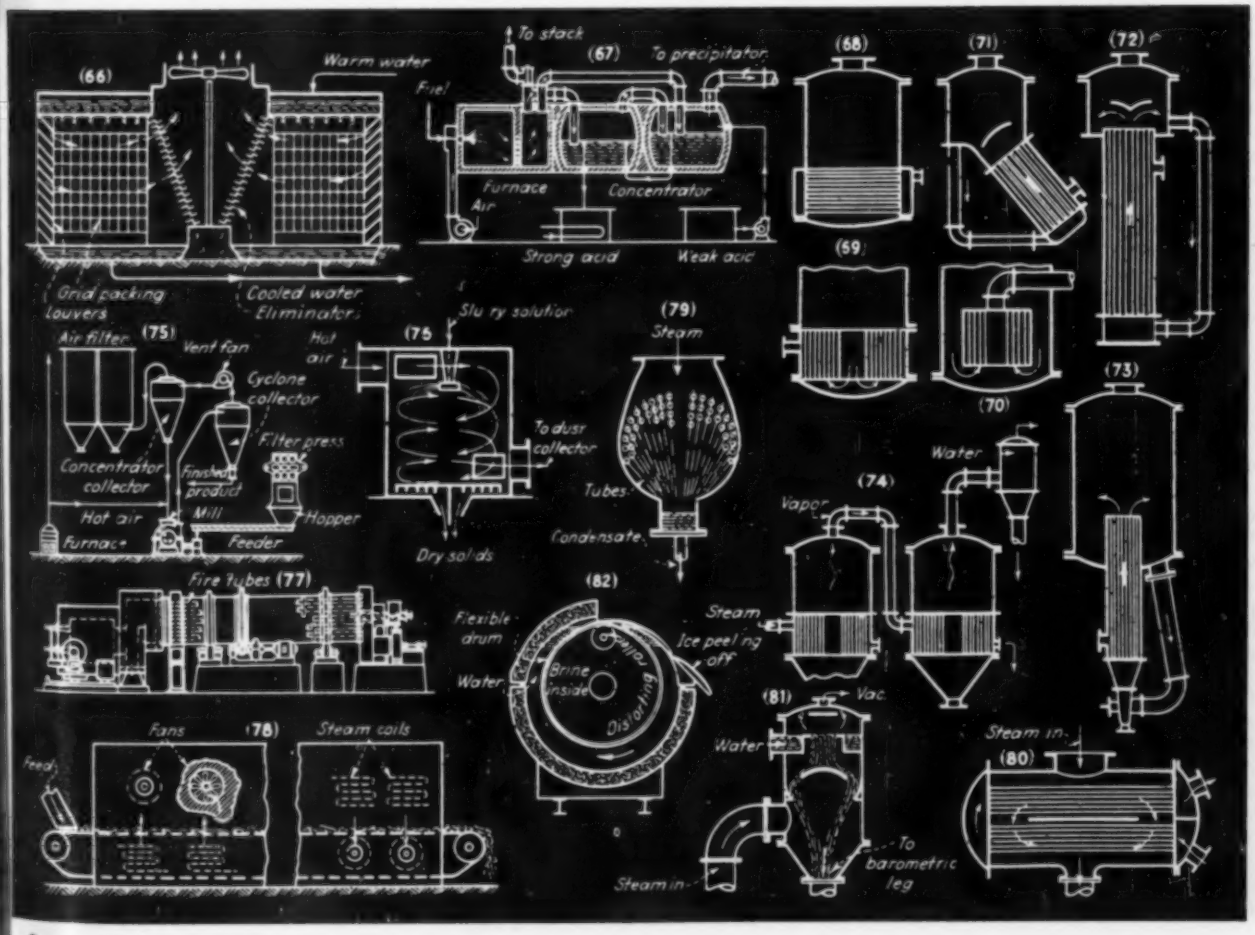
Cases of the indirect application of combustion gases to the evaporation of liquids are found in steam boilers. Comparatively low transfer rates result in this case. Steam boilers, for example, have overall coefficients from 1 to 3 B.t.u. per hr., sq. ft. and deg.F., in the case of free convection, and 2 to 10 B.t.u. for forced convection (Perry, "Chemical Engineers' Handbook," 2nd ed., McGraw-Hill, 1941). Where direct contact of the gases with the liquid can be achieved, better results from a transfer standpoint are obtained. An example is the Chemico double drum concentrator for sludge and weak sulphuric acid illustrated in Fig. 67. Another example of similar principle is the use of submerged combustion for evaporation, as typified by the Ozark Chemical Co. installation for sodium sulphate evaporation which was described by Douglass and Anderson (*Chem. & Met.*, 135–7, 1941). The method avoids transferring heat through sodium sulphate scale and involves moderate costs.

Steam heating is used for evaporation in many types of equipment. Figs. 68 to 74 illustrate typical evaporators and evaporator arrangements. With the exception of Fig. 73, all types shown employ natural circulation over or through the steam-heated tubes. In Fig. 74 a double-effect evaporator is shown, with the steam evolved from the first evaporator body used as the heating medium in the second body. In the handling of viscous materials, such as caustic soda solutions of higher concentration, forced circulation is sometimes used as in Fig. 73 to permit the attainment of high velocity and heat transfer.

DRYING

The numerous types of drying equip-

(66) Marley double-flow cooling tower; (67) Chemico double-drum concentrator for sulphuric and sludge acids; (68) Horizontal-tube evaporator; (69) Callandria type evaporator; (70) Basket type evaporator; (71) Evaporator with inclined tubes; (72) Natural circulation evaporation with vertical tubes; (73) Forced-circulation vertical-tube evaporator; (74) Double-effect Callandria type evaporator; (75) Raymond kiln mill for pulverizing and drying; (76) Simple spray dryer; (77) Bartlett & Snow fire-tube indirect-heat dryer; (78) Tunnel dryer of Proctor Aeroform type; (79) Typical large-capacity steam surface condenser; (80) Shell-and-tube condenser for vapors; (81) Typical falling-curtain type counter-flow barometric condenser; (82) Schematic cross section of Flakice machine; the drum distorts as it rotates, cracking off flakes of ice



ment may be classified broadly according to the main source of heat input which may include gases and radiation resulting from combustion, condensing vapors, and hot liquids. Direct-fired and hot air dryers represent the most numerous types. The Raymond kiln mill illustrated in Fig. 75 combines drying and grinding in one operation. The spray dryer, Fig. 76, has been used in the drying of a wide range of chemicals, as well as milk, eggs and other food products. Direct-fired rotary dryers and direct-indirect rotary dryers, in which the combustion gases make an indirect and a direct pass through the equipment, are common. Compartment, cabinet, atmospheric tray, truck and tunnel dryers are all found in this combustion-heated classification.

As it appears from Figs. 77 and 78, rotary and tunnel dryers may also be of the indirect-heated type. Fig. 77 shows a fire-tube rotary dryer for use where the combustion products should not contact the material being dried. Fig. 78, based on the Aeroform dryer, represents a tunnel dryer with heat provided by steam condensing in coils, conveyed to the material being dried by air which is reheated and recirculated. Steam heated dryers also include can or cylinder dryers for sheet materials, drum dryers, pan and agitator dryers, and vacuum tray dryers.

Radiant heat, usually accompanied by gas convection, is employed for heat transfer in a variety of high temperature dryers, including incinerators, compartment and tunnel dryers for high temperature operations. On the other hand, radiant heat, substantially alone, is the method of transfer in infra-red or heat lamp dryers and in the sludge beds of sewage plants. Bennett and Haynes (*Chem. & Met.*, 108–8, 1940) state that most of the infra-red radiation produced by heating lamps is in the wave lengths below 20,000 Angstrom units. Synthetic finishes are best adapted to this method of drying, the operation normally being completed in about 10 to 15 minutes. Tiller and Garber (*Ind. Eng. Chem.*, 34, 773–81, 1942) state that heating lamps of the gas-filled variety, with tungsten or carbon filaments, are giving service in excess of 10,000 hours.

CONDENSATION

Liquids, generally water or brine, are the media most widely employed for cooling and condensing vapors. Equipment in which there is an intervening wall between the vapor and the medium includes evaporative condensers, open-type sections, shell-and-tube type condensers and double-pipe condensers. For a large steam condensing load, as in conjunction with condensing turbines, shell-and-tube units similar to Fig. 79 are generally employed. For smaller steam condensing applications and for the handling of other vapors such as organics, horizontal shell-and-tube condensers similar to Fig. 80, or vertical condensers of comparable design are usual. According to Millett (*Ind. Eng. Chem.*, 30, 367–72, 1938), vertical tubes with radial fins have been employed extensively for solvent recovery. It is stated that aluminum extended surface tubes are used in this service, while copper and Everdur are also commonly employed for vapor condensers. Colburn ("Chemical Engineers' Handbook," 2nd Ed., 997–1,000) lists overall coefficients encountered in condensing and other applications.

There are two general types of condenser used for condensing steam by direct contact with the cooling water, the barometric and the low level jet condenser. The first type discharges through a vertical barometric leg long enough to permit the discharge of water by gravity alone while the second type requires a pump for removal of the water. Each type is available in both counter-flow and parallel flow designs and in each type the cooling water may be introduced either as a jet or as a falling curtain. Fig. 81 diagrams one of the many designs of barometric condenser of the falling-curtain type. Direct contact with the coolant has occasionally been used.

The refrigeration effect produced by an evaporating liquid, as in the evaporative cooler of Fig. 27, is sometimes used for the condensing of vapors. Pipes and open-type sections are suitable for this purpose as well as for air-cooled condensers. Ice and solid carbon dioxide have found occasional applications in condensation.

FUSION AND FREEZING

Use of liquid transfer media such as Dowtherm and hot oil has been employed for the melting of solids, as in the heating of caustic fusions in producing synthetic phenol and a variety of dyestuffs. The Frasch sulphur mining process is an example of fusion with a liquid medium, applying water at high temperature and pressure for this purpose. Gas convection and radiation also find application for heating caustic pots and sulphur dye fusions; and for heating electrolysis cells in the Hall aluminum process; for sodamide production; in heating glass tanks and furnaces; sodium silicate furnaces; rock wool cupolas; and for melting sulphur.

Condensing vapors as a heating medium are employed for melting in asphalt-emulsion production and wax processing, as well as in melting sulphur for sulphuric acid production. Electric heat is sometimes used for wax melting, as well as for the melting of glass for glass fiber production and in metal-melting arc furnaces. Most of the texts on heat transfer contain little information on rates of heat flow involved in fusion processes.

Operations where liquids are frozen are encountered typically in the flaking of caustic and of soap, and in the production of ice. Low temperature media for this purpose include water, at temperatures down to a few degrees above its freezing point, as well as various brines consisting of solutions of sodium or calcium chlorides. Water suffices for the higher temperature freezing range while brine is employed in ice manufacture, as for example in the Flakice machine diagrammed in Fig. 82, and in freezing of penicillin extract prior to final vacuum dehydration. In some applications a cold transfer medium is not used, and the evaporation of a boiling refrigerant can be used in indirect contact with the material as in oil de-waxing.

As has frequently been pointed out, high fluid velocities are of importance in heat transfer (e.g., Blaylock, *Chem. & Ind.*, 60, 213–14, 1941) and the trend toward the use of such higher velocities and other means for minimizing surface films will doubtless continue. The use of pumps and fans to achieve such effect is ordinarily justified by the reduced size and better performance of the equipment. From another aspect, the advantages of continuous heat transfer operations have become widely appreciated and it seems not unlikely that this trend will continue.

Further emphasis on improved construction materials is likely, since freedom from adherent corrosion products is as attractive from a heat transfer standpoint as is the longer life possible for equipment of corrosion resistant construction. The criterion here is evidently neither the price per square foot of exchanger surface, nor the heat transferred per hour per dollar of first cost, but rather unit cost of heat transfer throughout the life of the equipment. Another trend evident in the last few years has been the improvement in heat transfer characteristics of several of the non-metallic construction materials such as carbon and ceramics which in many cases formerly were considered unsuited for heat transfer.

What possibilities may exist for improving convection heat transfer by surface treatments of transfer materials, or by better methods of bringing about contact, only the future will show. Is there, for example, a possibility that further understanding of surface chemistry will enable film resistances to be minimized? The prospect is at least attractive.

In conclusion, the author wishes to express his appreciation for suggestions made by C. George Segeler, editor of the American Gas Association, and by M. L. Heminway of the Tubular Exchanger Manufacturers Association. Also, thanks are due to the following manufacturers of equipment who supplied information or illustration material for this article: Alco Products Div. of American Locomotive Co., New York; Alcorn Combustion Co., Philadelphia, Pa.; American Heat Reclaiming Corp., New York; The C. O. Bartlett & Snow Co., Cleveland; The Carborundum Co., Perth Amboy, N. J.; Davis Engineering Corp., Elizabeth, N. J.; Downingtown Iron Works, Downingtown, Pa.; Elliott Co., Jeannette, Pa.; Fansteel Metallurgical Corp., North Chicago, Ill.; Flakice Corp., Brooklyn, N. Y.; General Electric Co., Schenectady, N. Y.; Girdler Corp., Louisville, Ky.; Griscom-Russell Co., New York; Ingersoll-Rand Co., New York; The Marley Co., Inc., Kansas City, Kan.; Niagara Blower Corp., New York; North American Electric Lamp Co., St. Louis, Mo.; The Patterson-Kelley Co., East Stroudsburg, Pa.; R. C. A. Manufacturing Co., Camden, N. J.; Submerged Combustion Co. of America, Hammond, Ind.; Henry Vogt Machine Co., Louisville, Ky., and Wurster & Sanger, Inc., Chicago.

Reprints of this report are available at 50 cents per copy. Address the Editorial Department, *Chem. & Met.*, 330 West 42nd St., New York 18, N. Y.

JOHN R. CALLAHAM *Assistant Editor, Chemical and Metallurgical Engineering*

LIGNUM-VITAE
Wood for Processing Applications

Although long known in nooks and corners of the mechanical trades, lignum-vitae wood has had limited use in the processing industries. Yet bearings, bushings, rolls and other parts made of this unique wood, the hardest and most dense known, can dovetail for brass, bronze, babbitt and other metals in certain chemical applications. Being self-lubricating and non-contaminating under selected conditions, lignum-vitae is often ideal for use in the food, pharmaceutical, textile and other processing fields. This article lists some of the chemical case histories unearthed during a survey made by this magazine.—*Editors*

HARDEST, HEAVIEST and closest grained wood known: that's lignum-vitae. A native of the West Indies, the northern coast of South America and the west coast of Central America, this wood has been an article of trade since 1500. Although well suited for a wide variety of mechanical and chemical applications, remarkably little has been known about this wood, although several hundred tons monthly are normally imported into this country.

In prewar days, lignum-vitae was turned and machined into numerous odd and end items such as mallets, casters, dowels, bearings and bushings, spools, pulleys and guides. Many of these found their way into the nooks and corners of industry, mostly in mechanical applications. A few isolated cases of chemical uses were known, but detailed information on these was never known at large.

With the coming of war, however, lignum-vitae soon hopped up high on the materials priority list. An increasingly large part of the supply has since been going into ship construction; the self-lubricating properties, resistance to salt water and great compressive strength of the wood make it especially fitted for segment bearings in propeller shaft assemblies. It is estimated that well over 1,000 Liberty and Victory ships have been outfitted with lignum-vitae bearings since the beginning of the war.

When war necessity pinched off copper alloys from a large portion of their normal industrial uses, lignum-vitae dovetailed as an alternate material for many applications. In fact, long before the war this wood had been replacing brass, bronze and babbitt metal for bearings in specialized applications where its low initial cost, long life and self-lubricating properties show up to advantage.

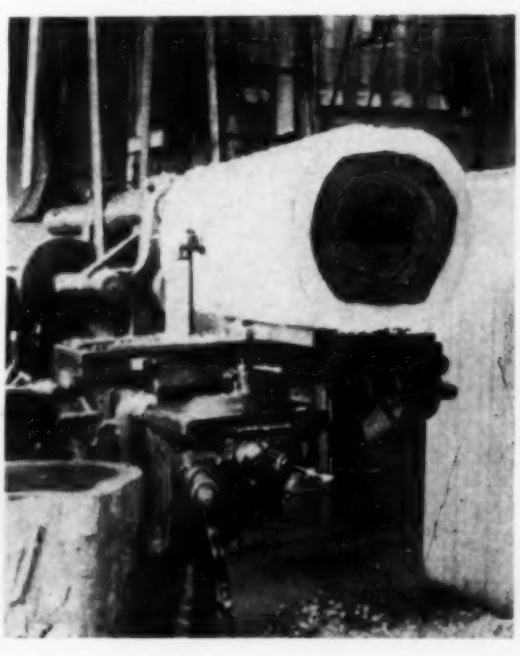
Postwar industrial uses of lignum-vitae will probably increase, especially as knowledge of its unique properties, proper use, and natural limitations become more widely known among engineers. In fact, this lack of specific data on the suitability of the wood for various applications has been its chief deterrent to a more widespread use in the process industries. This condition will be corrected after the war, however, for Lignum-Vitae Products Corp., Jersey City, N. J., leading importer of the wood and the world's largest manufacturers of tropical hardwood products for mechanical and industrial purposes, is equipping a laboratory to study the working mechanical and chemical behavior of lignum-vitae and other hard woods.

True lignum-vitae heartwood* is the hardest and most dense of all woods. The grain is very closely interwoven, resulting in the unusual density of 72-83 lb. per cu.ft. It is very difficult to split and is highly resistant to compression and ordinary wear. Lignum-vitae has the ability to withstand working pressures of 2,000 lb. per sq.in. The wood is usually dark in color; black logs are known as "nigger heads."

UNIQUE PROPERTIES

The high resin content of lignum-vitae, which runs about 30 percent of its volume, makes the wood self-lubricating, a property that comes in handy in many applications. This resin, known as "guaiac," has a pleasant balsamic odor and a deep reddish-brown color turning to blue-green upon oxidation. It is insoluble in water, weak acids and a number of chemical solutions. The resin is soluble in alcohol, ether and certain other organic solvents; these solvents thus destroy the self-lubricating

Log ready for machining into industrial parts at Lignum-Vitae Products Corp., Jersey City. Only 3.5 ft. long, this log weighs close to 400 lb.



* True lignum-vitae of commerce is the heartwood from the tree *Guaiacum officinale L.* and is superior to other similar woods sometimes marketed under the same name. These inferior woods are usually known to the trade as bastard lignum-vitae.

Table I—Properties of Lignum-Vitae Heartwood

Specific gravity	1.17–1.32
Pounds per cu. ft.	72–82
Hardness, Mohs scale (approx.)	3–4
Modulus of rupture, lb. per sq. in.	11,200
Max. crushing strength, lb. per sq. in.	10,480
Max. recommended working pressure, lb. per sq. in.	2,000
Resin content, percent of volume (average)	28–30
Expansion in water, percent of volume (approx.)	4
Max. recommended dry working temp., deg. F.	150
Diameter of heartwood, in.	4–24
Color	brown
Odor	balsamic

Lignum-vitae heartwood, however, is remarkably resistant to salt water, mild acids and alkalis, certain oils and bleaching compounds, liquid phosphorus, certain chemical solutions, and many food, drug and cosmetic compounds. In these latter uses it is valued because of its non-contaminating properties.

Ability of lignum-vitae to stand up far beyond any other wood was shown by a test on two pulleys identical in all respects except that one was made of brass and the other of lignum-vitae. At the end of a million revolutions the hole in the brass pulley had increased 1/16 in., while the lignum-vitae pulley had worn only a few thousandths of an inch.

Most lignum-vitae articles are worked on regular metal-working machinery. The Lignum-Vitae Products Corp., for instance, has been turning, machining, fabricating and finishing articles from lignum-vitae logs within tolerances of a few thousandths of an inch. Because of the basic nature of wood, a certain amount of subsequent shrinkage will take place. Thus it may become necessary to re-ream the part on the job, depending on the tolerance that must be maintained.

Immediately after finishing, the article should be covered with shellac or paraffin to preserve its resin-moisture ratio and to prevent cracking. Once the wood has attained its moisture equilibrium with the atmosphere or under working conditions, the coating is no longer necessary for protection.

Until comparatively recent years the value of lignum-vitae lay principally in the supposed medicinal properties of its resin, for centuries the hope (but not the salvation) of millions of syphilitics in Europe and elsewhere; hence its name "wood of life." Today considerable quantities of lignum-vitae sawdust are still treated with alcohol or ether to extract the resin for use in certain cough syrups.

Recently Swift & Co. has patented a process for using gum guaiac as an anti-oxidant to prevent lard from turning rancid in warm climates. The amount of guaiac necessary to accomplish this is very small, about one drop per pound of lard, yet this is probably the largest single use of the resin at present.

BEWARE OF LIMITATIONS

Many of the failures of lignum-vitae can be attributed to neglect by the user to take into account the natural limitations of the wood, since these, especially those of a chemical nature, have not always been widely known.

Size of lignum-vitae parts is usually limited, since most of the logs from which they are turned range from 4-24 in. in diameter and 4-6 ft. in length. This, however, does not always limit the size of the fabricated unit. Circular thrust bearings, for instance, can be made of matched segments to as much as 36 in. in diameter.

Lignum-vitae is not recommended for use where the applied or frictional heat generated is over 150 deg. F. unless operating or coming in contact with water or some other liquid which acts as a coolant. Excessive heat seems to decompose the resin and to cause the fibers to loosen.

Probably for the same reason, lignum-vitae parts should not be used at high speeds unless adequate cooling is supplied. In some applications a speed above 200 r.p.m. is not advisable, although lignum-vitae bearings on submerged phosphorus pumps have given very satisfactory service at 1,200 r.p.m. and 120–150 deg. F.

It is generally conceded that this wood should not be used under strongly acid conditions. Obviously such solvents as alcohol and ether will dissolve the resin from the wood, thus destroying its self-lubricating properties and rendering the part friable.

Table II—Typical Applications of Lignum-Vitae Wood in Chemical and Process Industries*

Submerged phosphorus pumps	bearings
Vinegar tank agitator	bushing
Weak sulphuric acid tanks	foot bearings
Powder shell loading	tamper
Beer tanks	bearings
Ammonium sulphite pumps	bearings
Soap mixing machine	rollers
Tumbling magnesium in oil	balls
Electroplating tanks	supports
Fruit cutting machines	guides
Alkaline cleaning solution	drain board
Drug mixing vat	studs
Copper chloride pumps	bearings
Bleachery equipment	squeeze rolls
Food handling equipment	bushings
High-pressure relief valves	balls
Rock crushers	thrust collars
Cosmetic cream vats	paddles
Beer pumps	piston rings
Roll crushers	rolls
Water treating tanks	foot bearings
Chromic acid plating baths	spools
Pharmaceutical equipment	friction blocks
Vinegar pumps	bearings
Shell loading conveyors	rollers
Milk tank agitators	bushings
Dye solutions	bearings
Food canning equipment	bushings
Incendiary mixing barrels	balls
Dye machinery	plugs
Exhauster valve	guides
Rubber squeeze roller	bearings
Deep well pumps	bearings
Slurry agitator tanks	guide bearings
Boric acid solutions	guide bearings
Hydrofluoric acid pumps	packing
Plating equipment	blocks
Cutting compounds	rollers
Salt brine vats	bearings
Cotton bleach tanks	guide bearings
Aluminum acetate tanks	bearings
Acid mine waters	balls
Textile machinery	bushings

* Since detailed and complete data on behavior of this wood toward various chemicals have not yet been determined, its suitability for each particular application must be determined experimentally.

CHEMICAL CASE HISTORIES

In order to determine to what extent lignum-vitae is being used in chemical applications, a survey was recently made over a wide range of process industries. The case histories given below are largely taken from the findings of this survey. Due to the lack of specific details for most of these cases, however, it is recommended that suitability of the wood under any given set of conditions be confirmed experimentally before actual installation

A Haitian trainload of lignum-vitae wood on its way to American industry

Over a period of five years, one firm found lignum-vitae bearings very satisfactory on submerged phosphorus pumps operating continuously at 1,200 r.p.m., and 120–150 deg. F., giving substantially longer life than either bronze or babbitt.

One oil company uses this material as a sleeve exposed continuously to copper chloride solution and abrasive action and has found it superior for this purpose to any other material ever tried. In addition, the lignum-vitae part was lower in cost. This firm, however, has had some difficulty in securing a good quality of wood.

A tannery, on the other hand, finds lignum-vitae considerably inferior to bronze as bearings on tanning drums at room temperatures. Similarly, a paint concern finds that the wood cannot take hourly exposures at 160 deg. F. and 100 r.p.m. to 15 percent sulphuric acid mixed with a fatty acid, coal-tar solvent and wood oil. Here the acid and solvent apparently attacked the lignum-vitae, leaving it soft and friable. This firm has used a considerable amount of this material over the last five years and considers it satisfactory for certain applications up to about 200 r.p.m.

Another firm uses lignum-vitae spools as retainers of glass panels in a 10 percent chromic acid solution. The wooden spools replaced laminated bakelite, which was more expensive and more difficult to machine. The lignum-vitae is not submerged in the acid, but is exposed to acid vapors and occasional acid washes.

FOR INCENDIARIES

Being spark-proof as well as chemically resistant, lignum-vitae balls are being used in mixing barrels for preparing incendiary materials for bombs and flares and for tumbling magnesium in oil.

The Kodak Park Works of Eastman Kodak Co. has used lignum-vitae for foot bearings in 4-5 percent sulphuric acid at 45 deg. F. and at 35 r.p.m. for a number of years, finding it to be the most suitable material available. There was little abrasion and maintenance was negligible. Other interesting applications of lignum-vitae at this works are listed in Table III. In general, experience at this plant indicates this material to be suitable in weak acid or neutral solutions at or below room temperatures and under ordinary conditions of pressure and abrasion, but unsuitable because of disintegration under higher operating temperatures, such as 200 deg. F.

Several hundred tons of lignum-vitae are imported to this country monthly

Kalunite, Inc., tried out a lignum-vitae bearing on an agitator revolving continuously at 200 r.p.m. and 68–100 deg. F. in a 15–30 percent potassium alum solution containing 1–2 lb. of crystals per gallon. Because of excessive wear, the bearing lasted only six months.

A war-industry application of the wood is as rollers for gravity flow conveyors at shell loading plants, replacing the rubber-coated steel rollers originally used. In this application, lignum-vitae has the advantage that it resists the action of cutting compounds that affect both steel and rubber.

Lignum-vitae rolls are also being used to replace stainless steel over vats in fabric bleacheries. In this service the wood showed only slight discoloration after four weeks of continuous contact with bleaching compounds; stainless steel corroded to the point of uselessness within three weeks. This wood is also widely used for bearings on certain textile machinery, since its self-lubricating properties reduce labor and maintenance costs.

Many food processing plants and dairies now prefer lignum-vitae to rubber for truck casters and rollers. Unlike rubber, the wood is resistant to many of the oils, acids and chemicals used in such plants. It is, unlike iron, unaffected by corrosive fruit juices; furthermore it does not contaminate the product. For these reasons, it is being used on vinegar handling equipment.

One steel concern found that lignum-vitae roll neck bearings on skelp and cold finishing mills gave very satisfactory service, lasting approximately ten times as long as bronze or babbitt bearings.

Table III—Present Uses of Lignum-Vitae Wood in Processing at Kodak Park Works *

Application	Exposure, hr.	Time Used, yr.	Mechanical Conditions	Maintenance Required	Reason for Use	Remarks
Roll crusher	2	8	High pressures and abrasion; low speed.	Negligible	Customary material for roll crushers.	Very satisfactory. Used for crushing hard lumps. Cracks fill with material, making change of product difficult.
Foot bearing in tank bottom: 4–5 percent sulphuric acid at 45 deg. F.	5	4–5	Low pressure, little abrasion; 35 r.p.m	Negligible	Most suitable material available.	No trouble; good service.
Foot bearing for agitator in water-treating tank: neutral solution at 70 deg. F.	Cont.	15	Low pressure, little abrasion; 75 r.p.m.	Negligible	Most suitable material available.	Very satisfactory. Tank solution muddy and gritty. Relatively unimportant in this operation if bearings become mushy or worn.
Bearing in a submerged pump; slightly acid solution, with small amounts of nitric or sulphuric acids at about 200 deg. F.	2	Lasted but 2 mo.	Low pressure, little abrasion; 1,200 r.p.m.	Continual	Nothing else available.	Very unsatisfactory
Sleeve bearing in grinder for solidified gel solution at 40–50 deg. F.	1	25	Low pressure, little abrasion; 300–400 r.p.m.	Negligible	Most suitable material to prevent contamination.	Satisfactory
Foot bearing in wash vessels; neutral solutions at 200 deg. F.	Cont.	Short time	Low pressure; slow, little abrasion.	Continual	Nothing else available at time.	All right in cold application. Heat seems to attack this wood more than acid. Part of lignum-vitae apparently dissolves and fibers become loose.

* Supplied through the courtesy of Eastman Kodak Co., Rochester, N. Y.

TRANSMUTED WOOD
May Have a Place in Chemical Equipment

Interesting results have recently transpired in the field of impregnation of wood to enhance its attributes as a material of construction through the use of various agents, the principal one of which has been phenol-formaldehyde resin solutions. Methylolurea resin treatment offers additional interest. The principal solute, dimethylolurea is now available on an industrial scale so that the process is commercially feasible. The treatment markedly improves the resistance of wood to the action of most chemical agents. It is termed "transmuted wood" and may find chemical process industries applications. — ***Editors***

Kiln drying of Methlyolurea impregnated wood

A PROCESS for treatment of wood has been developed which materially improves its mechanical characteristics and resistance to most chemicals. The method of resinifying methylolurea in the wood was developed by E. I. duPont de Nemours and Co. pursuing a line of research that paralleled studies conducted by the Forest Products Laboratory of the U. S. Department of Agriculture.

Methylolurea resin impregnation imparts dimensional stability to wood; improves its strength and hardness. Veneers which are sufficiently impregnated and dried become self bonding under heat and pressure; when incorporated into plywoods resist checking, warping, and splitting. The flame resistance of the wood is improved and it becomes more resistant to fungi, rot, and pest infestation. Treated timbers become markedly harder, stronger, stiffer and more durable. A hardened, dent resisting, high strength shell may be obtained by partial impregnation of construction lumber, leaving the untreated inner fibers in a more resilient, flexible state to withstand impact stresses. This allows the lumber to bear heavier loads or permits lighter construction. Complete impregnation for construction purposes is not economically feasible but partial impregnation is.

Chemical attack on wood is greatly reduced by the methylolurea treatment. Wood which was subjected to the vacuum-pressure impregnation was exposed to the action of various chemical agents. The results are listed in the table using the discoloration of wood as a criterion of t amount of attack. The treatment show the greatest resistance to nitric acid a after several hours in 25 percent soluti the wood showed little or no signs of action. The resistance may be further creased by subjecting the treated wood heat and pressure also by increasing t amount of methylolurea used for impr nation.

Conventional lumber treating cylind equipped for vacuum-pressure operati can be used for impregnating. Drying a polymerizing can be accomplished means of natural air or kiln.

Urea has long been a product of co merce but only recently has dimethyloli become available on a commercial sc While both materials are on allocation the War Production Board, small quan ties required for investigation and p liminary tests are available without allo tion. The cost of the chemicals is appro mately 8 to 9c. per lb. at the mill. Co plete impregnation requires approxima five pounds of methylolurea for aver lumber weighing 30 lb. per cu.ft. T cost approximates 3.5 to 4.5c. per bd Average veneer will cost about 0.15c sq.ft. Surface impregnation ranging fr ½ to 3 lb. of methylolurea per cu.ft. lumber will range from 0.3 to 2c. per bd

Resistance of Transmuted Wood to Chemical Attack

Wood	Treatment	Appearance of Wood After 15 Min. Immersion			
		25% HNO_3	70% H_2SO_4	25% HCl	10% NaOH
Cottonwood (sap)	Untreated	Dark brown	Black	Pale brown	Yellow
	Treated	No change	V. sl. discolor	Yellow	Lt. yellow
Cottonwood (heart)	Untreated	Brown	Black	Gray	Lt. yellow
	Treated	No change	Lt. brown	V. lt. yellow	No change
Bireh (sap)	Untreated	Dark brown	Lt. black	Brown	Brown
	Treated	No change	V. lt. yellow	Lt. yellow	Lt. yellow
Bireh (heart)	Untreated	Dark brown	Dark brown	Brown	Brown
	Treated	V. sl. discolor	V. sl. discolor	Lt. brown	Brown
Gum (heart)	Untreated	Brown	Dark brown	———	Brown black
	Treated	V. sl. discolor	V. lt. brown	———	Dark brown
Poplar	Untreated	Dark brown	Black	Lt. brown	Lt. brown
	Treated	No change	Lt. yellow	V. lt. yellow	Yellow
Douglas Fir	Untreated	Dark brown	Black	Lt. brown	Brown
	Treated	No change	Yellow-brown	Yellow	V. slight discolor

EDITORIAL STAFF REPORT

E.S.D. ENGINEERS

United for Service to Members and to Community

Engineers are necessarily individualists, and many of their accomplishments are the direct result of individual effort. On the other hand it is sometimes brought to our attention that a meeting of persons and ideas can and generally does produce a coordinated effort toward further accomplishment. To remind us of this principle and perhaps offer some constructive thoughts along this line we present the story of the Engineering Society of Detroit.—Editors

In spite of the oft repeated complaint that the engineering profession does not enjoy its merited national recognition along with such professions as the medical and legal, some organizations are moving ahead to prove their worth in their own localities. One particularly successful group is the Engineering Society of Detroit. A consideration of the organization and activities of this society leads one to the thought that if engineers were more generally united on a local scale, there might be increased appreciation of their importance to the nation as a whole. At any rate, the story of the progress and present activities of the E.S.D. should stimulate the interest of engineers in other cities.

It is not likely that every engineering society will acquire a building such as the Rackham Educational Memorial in Detroit, but that is only part of the story. The integration of engineers of all types into a single unit is one of the greatest triumphs for any such organization, for it is still true that in unity alone there is strength. Fortunately, the engineer invariably considers the strength gained from unity should be exerted in constructive, fair and cooperative activities. In this at least, the engineering profession is exemplary to the nation. Whether during peace or war, engineers and technical men are conscious that it is to them the country must look for conversion of its resources to meet the needs of its citizens.

One thing clear about E.S.D. is that it operates as a service both to its membership and the community. While some people today may pass off this business of "glorified" aims and objectives as just a meaningless part of the procedure in forming a society, the officers of E.S.D. are to be congratulated for their constant belief that if the society ceases to function primarily for service, it has no good reason for existence at all.

Detroit's first engineering society was formed just before the turn of the century and was known as the Detroit Association of Graduate Engineers of the University of Michigan. Shortly after its formation, it grew into the Detroit Engineering Society which continued to function through 1935 and the early part of 1936 when it was superceded by the present Engineering Society of Detroit. In the early 1920's, the old society had a fair sized membership of 900, but suffered heavily in the depression following 1929 when its membership dropped to less than 150. How the society has regained lost ground is seen by the fact that it is gaining about 50 new members each month, already has over 4000 members, is affiliated with between 25 and 30 national engineering and scientific societies and operates close to 30 committees.

To get back to the story, about the time the Detroit Engineering Society was at its lowest ebb in the early 30's, Dr. Bryson Horton, an engineer and founder of the Square D Co., as well as a trustee of the Horace H. Rackham and Mary A. Rackham Fund, petitioned his fellow trustees for aid in establishing the D.E.S. on a firm foundation.

The story of Horace H. Rackham and his charities is now fairly well known. Enriched by the returns from a small investment made during the organization of the Ford Motor Co., Mr. Rackham left a fortune of thirteen million dollars to be expended under the terms of his will "for public, civic, social and general welfare; the establishment, ownership, operation, maintenance and assistance of charitable, educational, benevolent, scientific, religious and other public activities and institutions already or hereafter established; and study, research and publication."

The Rackham Educational Memorial in Detroit; home of the E.S.D.

E.S.D. Objectives for Service to the Membership

1. To create and maintain an organization uniting all persons engaged in the professions of engineering and architecture or interested in the allied arts and sciences to the end that the material well being of mankind shall be served more effectively.

2. To provide a common meeting place and secretarial service for all local architectural and engineering societies and local chapters of national societies.

3. To broaden the outlook, increase the technical skill and improve the social vision of persons engaged in engineering activities by lectures, publications, classes of instructions and other methods, that engineering research, invention and more extensive utilization of the basic materials of nature shall continue for the enrichment and welfare of our people.

4. To provide new ideas and inspiration to the individual engineer by promoting and providing facilities for contact and discussion with other engineers of different experience and viewpoint.

5. To provide encouragement and facilities toward a continuing process of education for our younger engineers with the object of aiding them to find useful positions in society and making them conscious of their obligations and opportunities for service to humanity.

Coincidental with the negotiations between the Detroit Engineering Society and the Horace H. Rackham and Mary A. Rackham Fund, it was decided for various reasons issuing from a study of ways and means, to close out the old D. E. S. In reorganizing, the Engineering Society of Detroit was formed in early 1936 and incorporated under the laws of Michigan as a non-profit corporation.

One month after formation of E.S.D. the above-mentioned Fund made a gift of $500,000 to be administered by a new trustee organization, the Rackham Engineering Foundation. An additional gift of $500,000 by the Fund, a personal gift of $500,000 to the original trust by Mrs. Mary A. Rackham, and another gift of $750,000 from Mrs. Rackham jointly to E.S.D. and the University of Michigan resulted in plans being drawn up to provide a suitable memorial to Mr. Rackham. The building, as shown in the accompanying illustration, was completed and dedicated in January 1942.

Committees of E.S.D.

Advisory to Junior Section
Advisory on Personnel
Building Operation
By-Laws
Civic Affairs
Credentials
Executive
Finance
Friendship
Library Service
Membership
Mayor's City Planning Advisory
Postwar Exploratory
Program
Publication
Public Relations
Representatives to APELSCOR
Representative to Michigan Engineering Society
Sound Equipment
Traffic Control
Vocational Guidance
Wayne University Expansion
Wayne University Citizens Advisory Council

In the center of the building is the main auditorium designed to seat 1000 people and used jointly by the Society and the Extension Division of the University of Michigan. Directly under this auditorium on the ground floor is the Engineering Society's banquet hall with provisions for dining 650 people at once. The right section of the building is made up mostly of classrooms and administrative offices of the University's extension service. On the other side of the building lie the facilities of the Engineering Society of Detroit. In the Society's wing, there is an auditorium which seats 300 people and is adequate for many of the affiliate society meetings. There are numerous lounges and committee rooms, some of the latter having movable walls which can adjust the size of the room to the needs of the particular committee in session.

For the members' use there is a beautiful dining room with accommodations for 80 to 100 people and serving two meals (noon and evening) daily except Sunday. It is estimated that almost 8,000 meals are served here monthly. A recreation room complete with bowling alleys, billiard tables and a snack bar keeps the engineers entertained although up to now there hasn't been a lot of spare time for Detroit's war plant engineers.

Another pleasant room contains the society's library. Here in addition to reading tables, there are some standard reference works, but the accent is on recent and current technical publications. The reason for this is that there is close cooperation with the technological branch of the Detroit Public Library which is just a block away. One fairly large room is allocated for use by the junior members who carr on a sustained program to be described i more detail later. As a matter of fact, th building has worked out more efficient than the most optimistic had expected an has been a real source of satisfaction to a concerned.

ORGANIZATION

To guide the society and carry out it aims there is a board of directors con sisting of nine members, three of whom are elected each year for a three year term Chosen from resident members of the society, these men are of high calibre and among the leaders in their respective fields. To them goes a large share of credit for the admirable service of the society. It is interesting to note that the society's first two presidents, Mr. Harve M. Merker of Parke, Davis & Co. and Mr. T. A. Boyd of General Motors Corp are chemical engineers.

According to the by-laws of the society a member must be either a graduate of school legally authorized to confer a de gree in engineering, architecture, chemistry or related subject, or a person now or for merly engaged in the direction or prosecution of engineering, architecture, chemistry, or the allied arts and sciences. Local sections of national societies may become affiliate members of the Engineering Society of Detroit if at least 15 percent of their members are enrolled in E.S.D. In 1943 Detroit had about 7,650 members in local chapters of national societies affiliated with E.S.D. Of this membership, 22 percent or 1,650 were also members of E.S.D. and formed 45 percent of the 3,700 total.

As indicated earlier, there are facilities set aside in the Rackham Education Memorial building for use of the junior members. According to the by-laws of the society, a junior member is a person who has not attained his twenty-eighth birthday but who otherwise meets the qualifications of the regular members. The juniors act as a separate organization and operate under an advisory committee of the society which sets up their budget for activities and assists with general advice. They elect their own officers and have their own meetings, but of course are welcome at any time to attend the meetings of the senior members. At the present time about 50 percent of the junior members have been drafted for military service.

Generally there are some members of the junior section on the senior committees of the society. This is done to give them experience and train them for future activity in connection with the society as well as to keep the needs of the young members before the older ones.

One of the most important committees functioning in the Engineering Society of Detroit is the Committee on Civic

fairs. Composed of five members who meet bi-monthly for consultation, this committee is active in any and all civic affairs which can utilize its engineering experience and advice. The committee considers its responsibility is to define the problem rather than to solve it. In other words, their interest in civic affairs is purely from the engineering point of view and they have no desire to become mixed up with political arguments in any shape or form. The sole idea is to do all in their power to see that the public gets the best possible job. They are of course free to call on other members of the society for help or engineering advice in any problem which they may run across.

The committee has taken an active interest in the problems involved in regional planning and has worked closely with the Detroit City Plan Commission. In this connection, during the past year or so the committee has sponsored three meetings in an attempt to clarify problems. These meetings were addressed by men who are experts in this field and went a long way toward providing factual information for the final solution of the problems.

CIVIC COOPERATION

Civil authorities in Detroit have recognized the committee as an authority on engineering problems and more than once the society's committee has received assignments from the City Plan Commission. For instance, when the Regional Advisory Planning Committee of the City Plan Commission was surveyed the Detroit transit system with the idea in mind to recommend action which could be taken to improve it, the society's committee arranged a meeting for all interested parties and invited men who were expert in the transit field to come and give the benefit of their experience. The net result was that the City Plan Commission accepted plans offered by the Civic Affairs Committee of the society and passed these on to the mayor for his action. In the matter of airport facilities, it was practically the same story over again with the Civic Affairs Committee attempting to bring the proper parties together and aid in seeing the problem in its proper perspective.

The work of this Civic Affairs Committee was seen not long ago in connection with an indictment against the city as operator of a plant to burn the city's garbage. It had been claimed by neighbors around the incinerator plant that the condition of the plant was a health hazard to the surrounding residential district. Thereupon they obtained an injunction against the city. The E. S.D. committee investigated the problem, checked the operation of the plant, the treatment of the trucks used to haul the garbage, etc., and made their recommendations. The plant was revamped, operation was improved, conditions likewise noticeably improved in the neighborhood, the injunction was removed and everybody was happy.

It may appear from the foregoing that this committee works smoothly and encounters no difficulties whatsoever. However, such is not the case as each member of the committee is loaded down with responsibilities in his regular position, and can do committee work only in his own spare time. Only a real sense of responsibility to the community can motivate a committee with such accomplishments.

A Vocational Guidance Committee has been set up and is performing a valuable service. Once each year a meeting is held at E.S.D. for all the senior students in Metropolitan Detroit who are interested in engineering or science. After an inspirational talk, the group, normally about 600, divides into the respective engineering and science divisions. Then about 200 counsellors, representing topnotch men in their professions sit around tables with the students to discuss vocational matters.

E.S.D.'s meetings are held at least monthly under the arrangement of the Program Committee of the society. Generally a topic is selected which is of a technical nature but rather general in coverage since the audience will represent a good number of professions. Usually a dinner is served prior to the meeting, but in a separate dining room and not as part of the meeting. All members are welcome to the meeting without charge.

Each month the Engineering Society of Detroit publishes its organ called "The Foundation." In this there is the general news about the society, its members, its coming meetings and reports from the various committees.

The present endowment of the society amounts to approximately one million dollars which in addition to paying the society's taxes affords an income yearly of approximately $15,000 to the society. Obviously, this is far from enough to support the activities of the society and pay the expenses incurred in operation. Therefore, the larger portion of the society's income is gained from dues and initiation fees, and in small part from fees for use of the facilities of the building initiation fees amount to $10 for senior members and $5 for junior members. Annual dues for resident members are $14 if the member is also enrolled in an affiliate society or $16 if he is not so enrolled. For junior members this assessment is cut 50 percent. Non-resident members pay approximately 50 percent of the dues of residents.

E.S.D. has been described as "a rallying place for all persons engaged in engineering, science and architecture to discuss ways and means of close cooperation in order to perpetuate the search for increased enlightenment and knowledge, and to be of service to the community."

E.S.D. Objectives for Service to the Community

1. To assist the general public in understanding civic questions involving engineering problems by the promotion of open discussion and the publication of impartial information pertinent to civic engineering and construction problems.

2. To aid in promoting research and investigation upon engineering problems of public interest, particularly where the economic situation does not now provide proper support.

3. To provide assistance to industry, particularly the smaller industries, unable to maintain continuously adequate engineering staffs by supplying library service, and employment service supplying technically qualified men, and other facilities of the same type.

4. To cooperate with educational institutions by investigating candidates for scholarships and fellowships in engineering and applied science, and supporting scholarships, special instruction, or research.

Societies Affiliated With E.S.D.

American Ceramic Society
American Chemical Society
American Foundrymen's Association
American Institute of Architects
American Institute of Chemical Engineers
American Institute of Electrical Engineers
American Institute of Mining and Metallurgical Engineers
American Society of Metals
American Society for Testing Materials
American Society of Civil Engineers
American Society of Heating and Ventilating Engineers
American Society of Landscape Architects
American Society of Mechanical Engineers
American Society of Refrigerating Engineers
American Welding Society
Association of Iron and Steel Engineers
Illuminating Engineering Society
Industrial Electrical Engineering Society
Institute of Aeronautical Sciences
Michigan Engineering Society
Michigan Patent Law Association
Society for the Advancement of Management
Society for the Promotion of Engineering Education (U. of D. Branch)
Society of Automotive Engineers
Society of Plastics Engineers

FROM THE VIEWPOINT OF THE EDITORS—

S. D. KIRKPATRICK, Editor • JAMES A. LEE, Managing Editor • THEODORE R. OLIVE, Associate Editor • HENRY M. BATTERS, Market Editor
J. R. CALLAHAM, Assistant Editor • N. G. FARQUHAR, Assistant Editor • L. B. POPE, Assistant Editor • R. S. McBRIDE, Consulting Editor

WE BELIEVE IN INSURANCE!

DECISION regarding the production of ethyl alcohol from wood by way of wood sugar is being attempted in Washington under unfortunate conditions of controversy. Proponents of the plan to build a sawdust processing works in Oregon have had difficulty in getting approval for that project. Much of the delay was technical and unavoidable. But a recent denial of priorities for that plant seems to have ignored the most important policy factor.

The Chemicals Bureau of WPB recommended the granting of priorities, but the Requirements Committee of the same agency overruled their recommendation. Thus, at the end of April, the plant program was again held up. The facts regarding alcohol requirements are so clear that technical men, knowing the situation, cannot believe that this was a wise use of veto power in WPB. It has led to the outspoken charge that the decision was based on improper influence of certain members of the chemical process industries. That is a question that need not be discussed here. But there is another basic issue which does deserve review and thoughtful attention of many chemical engineers.

This important question has to do with the reasons why both OPRD and the Chemicals Bureau have sought to have this first demonstration plant built in Oregon. The plain truth is that American enterprise needs to know many more facts regarding the large-scale development of this process than we can ever secure under present circumstances. As an insurance against later difficulty we need the practical plant-scale operations which are proposed for the Willamette Valley.

It will be a great misfortune if the getting of those facts is long delayed. If later, as is likely, we may need still more alcohol production units in the United States, we should not have to choose our plants and plans without actual experience on sawdust alcohol. It will be too late to insure the house after the fire starts.

BUYER BEWARE

Now that salvaged equipment from dismantled war plants is beginning to appear on the market, a word of caution may not be out of order. Much of this equipment will have lost its identity in the sense that the guarantees of the makers are no longer valid or available. This may apply to practically new as well as to badly mistreated and overworked machinery. When sold in "as is" condition, the buyer may be taking an unnecessarily serious chance. It may pay him better, in the long run, to buy new or reconditioned equipment that carries with it the original guarantee of the manufacturer or of a responsible dealer in used equipment.

INDUSTRIAL SAFETY BY TRAINING

AN INTENSIVE course is being offered by numerous educational institutions to stimulate and educate both workers and supervisory personnel in the methods of industrial safety. The U. S. Office of Education and the U. S. Department of Labor have cooperated as a part of the war training work in the ESMWT program (Engineering, Science, and Management War Training).

Chemical engineers and executives will welcome this opportunity for short-course training, both for superintendents and for foremen. In most cases a 16-week period of training requires two sessions of two hours each in the evening. Many of the universities and colleges where engineering work is presented are planning such short-course service. Nearby institutions should be consulted by interested representatives of industry. The cost of this work is borne by the Government as a part of its organized effort to conserve manpower.

Where a local institution has not already planned a course of some desired type it can readily do so if there is an evident student demand. Such courses may be quite general or they may be highly specialized in nature, according to local need. There never will be a better opportunity to secure training for key personnel. Many chemical engineers should take advantage of this for their companies.

SAVE OR SUFFER

THERE is a connection between container board and white business or book paper which this war is now painfully bringing home to all of us. Every carton that goes overseas, and there are millions of them, requires unbleached kraft pulp to give it strength and capacity. To meet these needs for long-fiber pulp the kraft mills must now be pushed to 110 percent of their normal capacity—and they must meet this goal during the second quarter of 1944 despite the terrifying demands of the draft boards and the lack of trucks and adequate transportation facilities. What if they can't or don't? The only alternative is a still further cut in the use of white paper—perhaps as much as 25 or 30 percent—on top of present restrictions. Such drastic measures would greatly curtail the efficiency of most office and business operations and would prevent the publication of many essential books and magazines.

All of us can help in meeting this emergency if we will personally take a hand in policing our own individual and company operations to make certain that paper is used only for essential needs and that once it has filled these needs, waste paper is carefully collected and promptly returned to those who can process it for containers and other vital uses.

DUCKS AND GEESE

WHO's winning the war? And with what? One 3-star general just returned from our principal battlefronts reports that the doughboys rate our contributions in the following order of increasing effectiveness: Ducks, P-38's, C-47's, 2½ ton trucks, jeeps, bulldozers, sulfa drugs and blood plasma. The same observer noted that the majority of the actual weapons with which we are now fighting are not those with which we started the war. Does not that mean we must go slow in cutting down on research and development work in our universities and war industries? They are the geese that lay the golden eggs.

MORE FOR THE RECORD

ON THESE pages last month we called attention to a questionnaire of the National Roster which might have the ultimate effect of classifying chemical engineering as a minor branch of chemistry. Earlier in April at the Cleveland meeting of the American Chemical Society, the hotel lobbies buzzed with repercussions of the Council's action in approving a new definition of the chemist. Various gradations of training and experience were noted but all went back to the basic requirement of having completed an acceptable college course in chemistry or *chemical engineering* (the italics are ours). Thus it seemed to be generally agreed that every graduate chemical engineer might qualify under the A.C.S. definition as a chemist, although obviously the reverse could not be true of laboratory chemists or others without engineering training and experience.

Those who opposed the Society's legal counsel in setting up this official definition argued that it should have been worked out jointly with the American Institute of Chemical Engineers whose recommendations on the accrediting of chemical engineering curricula have already been accepted by the A.C.S. Now, according to advice passed along informally by responsible spokesmen of the Society, it is up to the Institute to produce its own official definition of the chemical engineer, having in mind the legal needs for meeting certain current situations that arise in connection with the administration of the various labor laws and regulations. We have no argument on this score with those who would serve both "chemists and chemical engineers," but we would remind them that the original definition used by the Institute in its accrediting program was that of the late Dr. Arthur D. Little and it clearly differentiates between the two fields in the following words:

> "Chemical engineering, as distinguished from the aggregate number of subjects comprised in courses of that name, is not a composite of chemistry and mechanical and civil engineering, but is *itself a branch of engineering*, the basis of which is those unit operations which in their proper sequence and coordination constitute a chemical process as conducted on the industrial scale." (Again, the italics are ours.)

That 1922 definition helped to establish chemical engineering as a distinct profession and since then less and less has been heard about chemical engineering being a branch of chemistry. Accordingly, in 1935 the Institute's Committee on Chemical Engineering Education apparently decided that there was no longer any need for the rather negative approach in the Little definition and it therefore adopted a more positive statement of what chemical engineering is in its relation to the basic sciences of chemistry, physics and mathematics:

> "Chemical engineering is that branch of engineering concerned with the development and application of manufacturing processes in which chemical or certain physical changes of materials are involved. These processes may usually be resolved into a coordinated series of unit physical operations and unit chemical processes. The work of the chemical engineer is concerned primarily with the design, construction and operation of equipment and plants in which these unit operations and processes are applied. Chemistry, physics and mathematics are the underlying sciences of chemical engineering and economics its guide in practice."

Perhaps it is time to re-evaluate and re-define the chemical engineer and, for the benefit of the minority that have refused to accept the inevitable logic of history, to re-affirm with Dr. Little that chemical engineering is a branch of engineering and not of chemistry.

WHAT IS "SURPLUS"?

MINERAL industry executives are seeking to tie up large mineral and metal stocks by having them transferred from the surplus category to a "stockpile" status. This effort may have serious consequences for mineral-consuming industries if followed in the extreme form which some of the proponents urge. Those likely to be affected should investigate and act now to avoid later more serious industrial controversy.

Many of the commodities involved in this discussion are imported minerals or are metals which have been scarce during the war period. Excess supplies above current consumption have been made available by the improvement of sea transport and by strenuous measures for domestic production. Domestic producers are now fearful that the large quantities which have accumulated will hang over the market as a threat, possibly even compelling a shutdown of domestic production. They argue for huge stockpiles of these materials which might again become scarce, were there another interruption of supply.

When spokesmen of the mineral industries apply this theory conservatively, they receive official support and should have the cooperation of the user industries. Some go too far. Some ask that all these stocks be impounded. Some argue that because the minerals and metals have once been scarce we must never let go of a pound, even those in excess of any normal stockpile need.

Unfortunately, these proponents have the attentive ears of 24 Western senators who form a close-knit mineral and mining bloc. That group, especially in an election year, is inclined to listen to these arguments and even to urge their adoption in an extreme form. Chemical process industries which will use many of these commodities, occupy an intermediary but strategic position between the producers of raw materials and the consumers of ultimate products. They want stable, competent suppliers to continue in existence. But they do not want to compel the ultimate customer to pay extravagantly for such stability of business.

This matter is going to become a serious political issue in Washington this summer. We should prepare to meet it and to aid executives and legislators in the formulation of a sound mineral policy to protect all parties fairly.

PROCESS EQUIPMENT NEWS

THEODORE R. OLIVE, Associate Editor

THREE-WAY VALVE

TYPE 604 is the designation of a three-way butterfly valve, on which a patent application is pending, recently developed by R-S Products Corp., Wayne Junction, Philadelphia 44, Pa. The new valve is designed for quick interchange and mixing service at all pressures from 15 to 900 lb. per sq. in. As shown in the accompanying illustration the valve consists of a three-way body in two legs of which are butterfly closure elements. These are adapted to either manual control or power operation, and are suitable for elevated temperatures. The unit shown, which is motor operated, weighs 8,500 lb. It is provided with dual finned, lubricated stuffing boxes for high temperature and pressure.

TEMPERATURE CONTROL

COMPENSATED for wide ambient temperature change, the Type K Thermostat has been developed by United Electric Controls Co., 69-71 A St., Boston 27, Mass. Simple in design and containing no delicate mechanism, it is said to withstand vibration, shock and moisture conditions. Various models of this instrument cover calibrated ranges of 300 deg. F. or 550 deg. F., between the limits of −120 deg. F. to +600 deg. F. These units have a differential operation of from 0.5 to 1 deg. F. in liquids, sub-zero testing cabinets and mechanical convection ovens, to 2 deg. F. in gravity type ovens. There is said to be no difference in the performance of the control at any temperatures within its range limits.

Owing to ambient temperature compensation the unit is able to employ a solid liquid-filled bellows, bulb and tube assembly. Among the advantages claimed for this type of thermal assembly are uniform bellows motion per degree and fast response. Application of this motion to a sensitive snap acting switch produces close differential equal at all temperatures.

Positioning the switch by means of a micrometer permits close adjustment. The micrometer adjustment covers a uniform amount of range for each complete turn. The instrument is made in a variety of modifications including multiple switches, fixed adjustments, remote dials, rate-of-rise response, and variations of range and differential.

COMBUSTION CONTROL SYSTEM

A NEW SYSTEM of combustion control, designed particularly for smaller power plants such as those used industrially, has been developed by Leeds & Northrup Co., 4934 Stenton Ave., Philadelphia 44, Pa. This system is said to supply regulation as effective and reliable as the company's Metermax system for large central stations. Known as Type P, the equipment is applicable to boilers fired with coal, oil or gas. It continuously proportions fuel and air to steam supply and at the same time controls furnace pressure. A simple electrical balance principle is employed by which the setting of valves, dampers or vanes is varied in definite proportion to steam demand and directed by a master controller. If desired, any of the drive units may be controlled manually as well as automatically. This is accomplished from pushbutton stations on the main panel. Independent operation of the drive units allows the controllers to be serviced without interruption of boiler operation.

STEAM GENERATING UNIT

FOR USE IN all industries where quick steam is needed for processing, power, or heating, a new compact steam boiler meeting A.S.M.E. requirements, known as the O & S Powermaster, has recently been announced by Orr & Sembower, Inc., Reading, Pa.

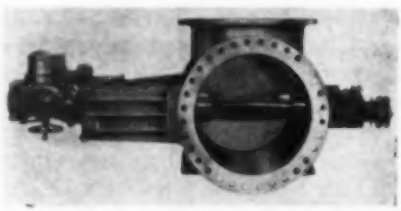
The boiler is said to develop 100 lb. pressure from 60 deg. water in 18 min. or less. Of three-pass construction, the boiler is claimed to minimize carbon collection and to require little cleaning. When it is necessary, simply removing the back plate permits easy access to the tubes. The special oil burner gives the flame a rotary motion which results in the flame hugging the wall of the combustion chamber. This assures longer gas travel and greater heat transmission. The built-in condensate return system is compact and easy to install, and either return condensate or water direct from the supply line, or both, may be used as feed water.

Pre-tested at the factory, wired and mounted, only the connection of the four services—electricity, water, oil and steam—is necessary to put this unit in operation.

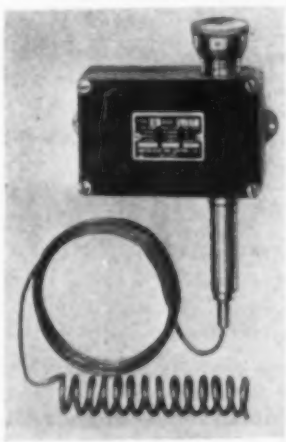
OUTDOOR WELDER

NEW all-weather models of the Wilson Bumblebee a.c. arc welder in capacities of 300 and 500 amp. have been announced by Wilson Welder & Metals Co., 60 East 42nd St., New York, N. Y. The new machines are similar to this company's standard Bumblebee a.c. welders, except that they have special moisture-proof insulation throughout and all parts are protected by a heavy coating of moisture-proof paint. A durable weather-resisting enamel is used for the outer case which is equipped with gaskets and louvers designed to prevent the entrance of rain. The equipment

Three-way butterfly valve

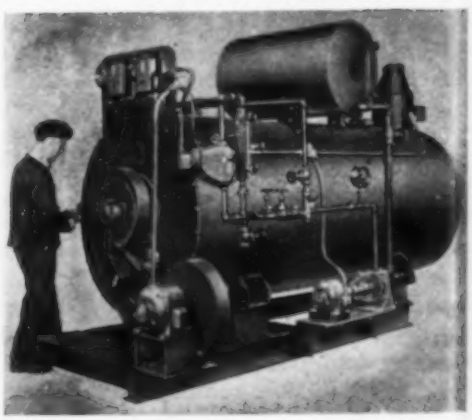


Micrometer-set controller



Type P combustion controller

Compact steam boiler



includes a low-voltage contactor which automatically holds the open circuit voltage at approximately 40 volts. When the operator strikes an arc the low-voltage contactor closes instantly and the transformer performance thereafter equals that of machines not similarly equipped. When the arc is extinguished this device immediately returns the voltage to 40 volts.

PLASTIC MANOMETER

DEMAND for unbreakable gages, both portable and stationary, to check pressures in boiler settings and air conditioning units, has led to the use of Tenite cellulose acetate butyrate in manometers manufactured by F. W. Dwyer Mfg. Co., Chicago, Ill. Manometers in which shatterproof Tenite replaces glass tubing are said to be rugged, yet easy to read and accurate. The seamless tubing is threaded at the ends for screw caps, and is easily bent into the desired shape. L-connectors of smaller tubing provide a convenient means for opening the gages for the addition of manometer fluids such as water, oil and mercury. Also a means for venting the gages to the atmosphere, the L-connectors are tapered and pressed in to make leak-proof connections.

PORTABLE DUST COLLECTOR

UNITS ranging in capacity from 300 c.f.m., up, are available in a new complete line of bag-type portable dust collectors, which have just been put on the market by the Northern Blower Co., 6502 Barberton Ave., Cleveland 2, Ohio. These units have up to 8 in. static pressure at the fan and are designed for light dust loads and intermittent service, being equipped with motors ranging from ¾ to 3 hp. The bags are cleaned by hand-shaking. These units apply the same principles used in this company's bag-type systems for large-scale dust collection, in that they have cylindrical bags, with the dust-laden air entering at the bottom and flowing upward inside the bags against gravity. They are claimed to have wide application in chemical laboratories, and in batch processing, mixing and packaging of dry powders. When confined to a single process, the recovered dust is salvagable.

OIL RECLAIMER

CONTINUOUS and automatic operation in the reclaiming of used lubricating oils is possible with a new line of "Robot" oil refiners announced by the Youngstown Miller Co., Sandusky, Ohio. Utilizing common refinery earths available in the open market, these reclaimers are said to remove fuel dilution, acids, solid and colloidal carbon, dirt and similar matter, and to restore oil that has emulsified with water. They are claimed to restore used oils to substantially the same fire, flash, viscosity, color, neutralization number and precipitation number as the new parent oil. A single machine, it is said, can be installed to serve an entire power plant, whether large or small. It is also claimed that this machine can restore transformer oils to 30,000 volts dielectric strength.

LOUVER BUBBLE CAP

RECENTLY developed by the Brighton Copper Works, Brighton Station, Cincinnati 4, Ohio, is a new louver-type bubble cap for use in fractionating columns. The cap is of pressed metal, permitting the same bubble-colliding action as cast bubble caps. The illustration shows how collision is effected. The cap is pressed from 14 ga. material and is available in stainless steel or copper. While the standard size cap is 3 in. diameter, caps can be manufactured in any size desired.

EQUIPMENT BRIEFS

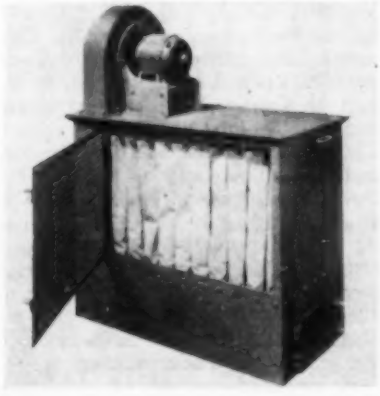
SUBSTITUTION of fluorescent glass standards for chemical solutions used for the calibration of fluorometric instruments has been proposed by the Scientific Bureau of the Bausch & Lomb Optical Co., Rochester, N. Y. Depending on the chemical constitution and the history of the particular melt, most transparent glasses are said to exhibit strong fluorescence. Though some glasses become fatigued under continuous irradiation, the company has developed particular types of glass which are constant and therefore suitable for standards for fluorometric determination. These glass standards, made in the form of blocks, will replace the liquid filter holders normally used for standard solutions, and once set up and accurately calibrated will serve as a permanent secondary working standard against which an instrument may be easily and quickly checked. Several advantages are claimed.

THERE has been a good deal of confusion concerning the distinction between fire extinguishers bearing standard Underwriters' Laboratories approval and those bearing the Laboratories "EAS" approval. The usual label reads "Underwriters' Laboratories Inspected" and gives the serial number of the label and pertinent information on the classification of the extinguisher. It signifies that the unit conforms to the Laboratories' prewar specifications. Such extinguishers are now available only to very high priority holders. The addition of the "EAS" to the label signifies that substitute materials have been used and that, although the model will perform as well as the standard model, it will require more careful maintenance and will not stand up as long as the standard type. When standard equipment is once more obtainable the "EAS" approval will be withdrawn.

New a.c. arc welder

Tenite manometer

Portable dust collector



Automatic oil reclaimer

Louver-type bubble cap

CHEM. & MET. PLANT NOTEBOOK

THEODORE R. OLIVE, Associate Editor

War Bond Awarded Each Month

Until further notice the contest which was first announced in our November 1943 issue will be continued. For the best short article received each month and accepted for publication in the "*Chem. & Met.* Plant Notebook," a $25 Series E War Bond will be awarded, in addition to payment at our usual space rate for this department. The award for each month will be announced in the issue of the following month. The judges will be the editors of *Chem. & Met.* Any item submitted may be published in this department, but all items so published will be paid for at our usual space rate for such material.

The contest is open to all readers of *Chem. & Met.*, other than employees of the McGraw-Hill Publishing Co., Inc.

Any number of entries, without limit, may be submitted by one person. Articles must be previously unpublished, and should be short, preferably less than 300 words, but should include one or more illustrations if possible. Finished drawings are not required and literary excellence will not be a factor in the judging. Winning articles will be selected on the basis of appropriateness, novelty and the usefulness of the ideas described.

Articles may deal with any sort of plant or production "kink" or shortcut which in the opinion of the judges will be interesting to chemical engineers in process industries, as well as with cost reducing ideas, and novel means of presenting useful data. Material to be entered in this contest should be addressed to Plant Notebook Editor, *Chem. & Met.*, 330 West 42nd St., New York 18, N. Y.

APRIL WINNER!

A $25 Series E War Bond will be issued in the name of

W. A. WELCH
West Virginia Pulp & Paper Co.
Philadelphia, Pa.

For an article dealing with an improvement in the method of operating pressure filters which has been adjudged the winner of our April contest.

This article will appear in our June issue. Watch for it!

March Contest Winner

SIMPLIED METHOD FOR ORIFICE DESIGN COMPUTATIONS

A. EDGAR KROLL
Chemical Engineer
Terre Haute, Ind.

IN THE DESIGN of orifice plates for measuring the flow of fluids through pipe lines it is necessary to compute the proper orifice size so that the pressure drop across the orifice is moderate. If the pressure drop is too large manometer readings may be impractical; if too small, readings will be inaccurate. In the case of too large a pressure drop there will be an excessive waste of power since part of the pressure drop is permanently lost.

In the following the terms are: C = flow coefficient; d = diameter of orifice, inches; D = internal diameter of pipe, inches; g = acceleration due to gravity, feet per sec. per sec.; G_1 = specific gravity at operating conditions; G_2 = specific gravity at 60 deg. F.; H = maximum differential pressure, in. mercury under water; $L = (H \times G_1)^{\frac{1}{2}} \times 1/G_2$; p = density, lb. per cu.ft.; P = differential pressure across orifice, lb. per sq.in.; Q_L = maximum rate of flow, gal. per hr.; Q_s = maximum rate of flow, lb. per hr.; $S = (H/sv)^{\frac{1}{2}}$; sv = specific volume at absolute pressure existing at the orifice; cu.ft. per lb.; and w = gravimetric rate of flow, lb. per sec.

Orifice calculations are based upon manipulating the unknown factors in the fundamental flow equation: $w = (C_4^2 \pi/48)\ (2gp\ \Delta P)^{\frac{1}{2}}$, or $d = 48w/C\pi)^{\frac{1}{2}}\ (1/2gp\ \Delta P)^{\frac{1}{2}}$. It is obvious that if the second equation is to be used for calculating the orifice diameter, d, a fourth degree equation must be solved. However, it is customary to make trial calculations in order to eliminate solving a fourth degree equation. For example, referring to the first equation ΔP is first selected making it as large as is practical for accurate readings and allowable head loss. Next, a value for d is arbitrarily chosen, and from the orifice ratio d/D, a value for C is found from curves or tables on flow coefficients[1]. These values are then placed in the equation and the equation is solved for w. If an approximate value for the maximum flow through the pipe line is known, the value for d is altered until the desired value for w is obtained. This method makes orifice design tedious and time-consuming.

A simplified method for determining proper orifice size directly in one calculation is made possible by plotting d/D vs. K, as in the chart, where for liquids

$$K = Q_L/LD^2;\ L = (H \times G_1)^{\frac{1}{2}} \times 1/G_2$$

and for steam

$$K = Q_s/SD^2;\ S = (H/sv)^{\frac{1}{2}}$$

Substituting known values in these equations, solving for K, and referring to the chart for the value for d/D make orifice size determinations relatively simple. This eliminates trial calculations, assumptions and reference to tables or graphs for flow coefficients. Plotting values are given on the chart to permit its reproduction to large size.

Use of the simplified method is illustrated in the following example:

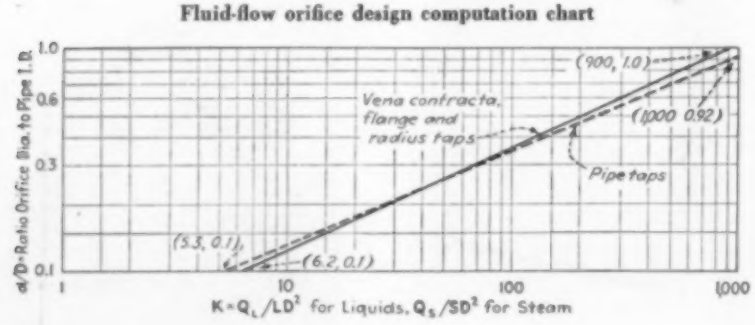
The maximum flow of steam through a 13.38 in. i.d. pipe is estimated to be 63,000 lb. per hour. What would be the diameter of the orifice hole to obtain a 7.0-in. mercury manometer differential pressure? Flange taps are to be used.

$$S = (H/sv)^{\frac{1}{2}} = (7.0/2.42)^{\frac{1}{2}} = 1.70$$

$$K = Q_s/SD^2 = 63{,}000/(1.70 \times 13.38^2) = 207.2$$

From the chart for K equal to 207.2 we find $d/D = 0.51$. Therefore, $d = 0.51 \times 13.38 = 6.82$ in. The diameter of the orifice should be 6.82 in.

Fluid-flow orifice design computation chart



References

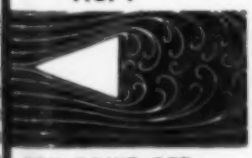
1. A.S.M.E., Research Publication, "Flow Meters, Their Theory and Application," 1937, 4th Ed., part 1, pp. 35, 109, 111-123.
2. Rhodes, "Industrial Instruments for Measurement and Control," McGraw-Hill Book Co., Inc., New York, 1941, pp. 195-26

HOLDS THE PRESSURE SETTING VERY *Accurately . .*

CASH STANDARD *Streamlined* TYPE 1000 PRESSURE REDUCING VALVES

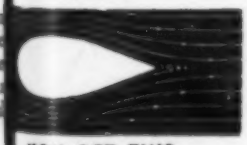
THE "Type 1000" Valve gives users absolute control of pressures. The reduced pressure is held constant regardless of variations in the initial pressure or variations in demand.

FIG. 1



YOU DON'T GET THIS TURBULENCE

FIG. 2



YOU GET THIS STREAMLINED FLOW

This operating feature eliminates all chance of changes occurring in the processing or of damage to product.

When there is peak demand to be met, your "1000" Valve is easily able to do it, holding the pressure constant at the same time.

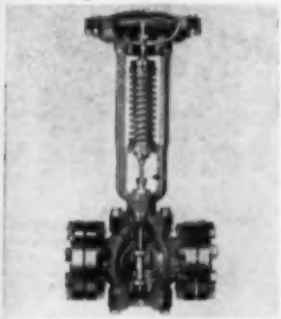
There is no downstream turbulence in your "1000" Valve. (See Fig. 1). The flow of steam, air, oil, etc. is streamlined (see Fig. 2) for straight flow through the delivery passage and jet. All of the process of pressure reduction occurs where the valve throttles flow and not on the downstream side of the valve. That is one of the feature results of streamlining. Therefore, there is no downstream turbulence and you have close delivery pressure control at all times.

Write for Bulletin "1000"

CASH STANDARD CONTROLS . . VALVES

A. W. CASH COMPANY
DECATUR, ILLINOIS

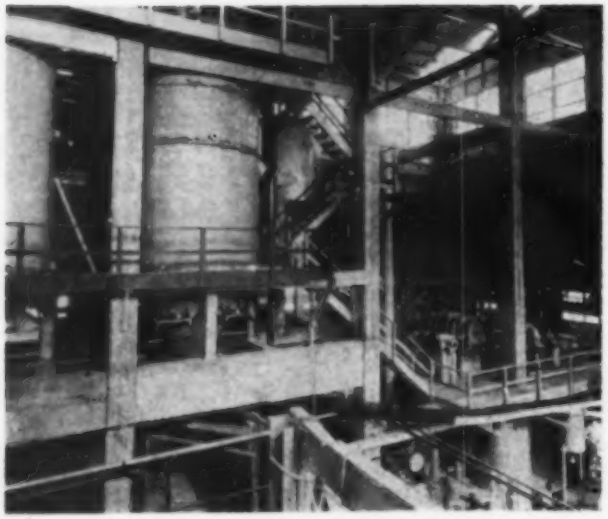
OTHER VALVES *from the* CASH STANDARD LINE



Cash Standard Type 33 Relief Valve; in various metals to handle nearly all fluids. Has Roller guides on valve spindle; also roller bearing to take care of spring torsion. Sizes ½" to 3" screwed ends; 1" to 12" flanged ends. Bulletin 971.

Cash Standard Type Q Relief Valve has side inlet, bottom outlet. Popular for pump by-pass use. Sizes ½" to 2" screwed ends. Relief pressures up to 350 lbs., temperatures up to 500°F. Bulletin 943.

Cash Standard Type 4190 Valve for relief (bypass) use; holds constant valve inlet pressure regardless of changes in load or outlet pressure. Multiport—large capacity. Iron or bronze bodies; iron or bronze trim. Sizes ½" to 2" screwed ends; 2" to 6" flanged ends. Bulletin 952.



1 At Carlsbad, carnallite is crystallized in vacuum cookers and separated by means of filters

2 Dilute magnesium chloride is concentrated in Oz merged combustion evaporators and dried in spray dr

A *Chem & Met* FLOW SHEET

MAGNESIUM FROM MINERALS

LANGBEINITE, which is the double sulphate of magnesium and potassium, has so far been mined in this country only from the potash deposits of the International Minerals and Chemical Corp. at Carlsbad, N. M. Its magnesium content, in combination with that of dolomite quarried near Burnett, Tex., is now the basis for the unique chemical and metallurgical operations shown in the accompanying flowsheet.

Langbeinite ore is mined from the 800-ft. level of the International mine at Carlsbad. Here a process has been developed for treating langbeinite after purification with sylvite (KCl), thereby precipitating potassium sulphate and leaving a mother liquor containing approximately 13 percent of magnesium chloride in a total concentration averaging about 30 percent of contained solids. It is from this complex saline brine that magnesium chloride must be separated and carefully purified for use as cell feed in the electrolytic magnesium plant.

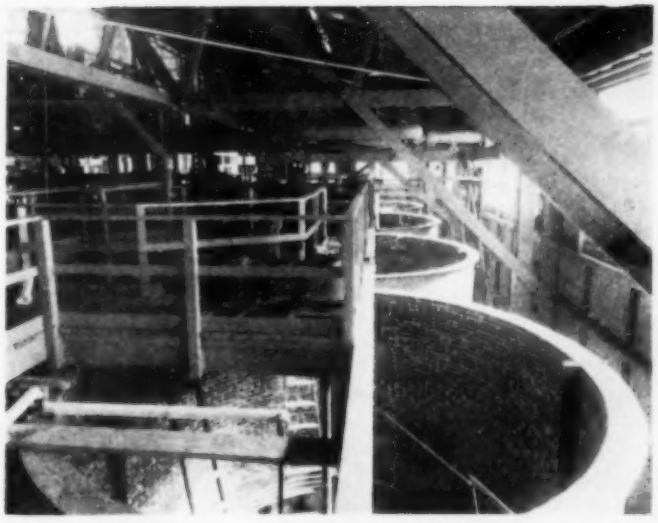
The purification process was consummated only after careful study of phase relationships which indicated that with proper control of concentrations and temperatures, carnallite ($KCl.MgCl_2.6H_2O$) could be crystallized from the system and later decomposed to yield magnesium chloride of desired purity. This must then be concentrated in an Ozark submerged combustion evaporator, chilled to remove the remaining KCl as carnallite, and after filtration the liquor is passed to Peebles spray dryers for the final dehydration. The powder from the dryer is briquetted and shipped to Austin, Tex., where it is electrolyzed in the modern Dow-process plant which was designed and is operated for the Defense Plant Corporation by International Minerals and Chemical Corp.

Magnesium chloride cell feed from Carlsbad forms only a part of that supplied to the electrolytic cells at Austin. The balance is made from selected dolomite, quarried at Burnett, Tex., calcined in a rotary kiln and processed to produce magnesium hydroxide. Hydochloric acid, made from the chlorine liberated in the magnesium cells, is used to convert this to magnesium chloride which is also concentrated in Ozark evaporators, and finally dehydrated in shelf-drying equipment of Dow design. The electrolysis of the fused salts to produce magnesium metal follows the standard practice which has previously been described in these pages. (See *Chem. & Met.*, November, 1941, pp. 73-84 and 130-3.) Complete description of this process is on pp. 92-96 of this issue.

CHEMICAL & METALLURGICAL ENGINEERING

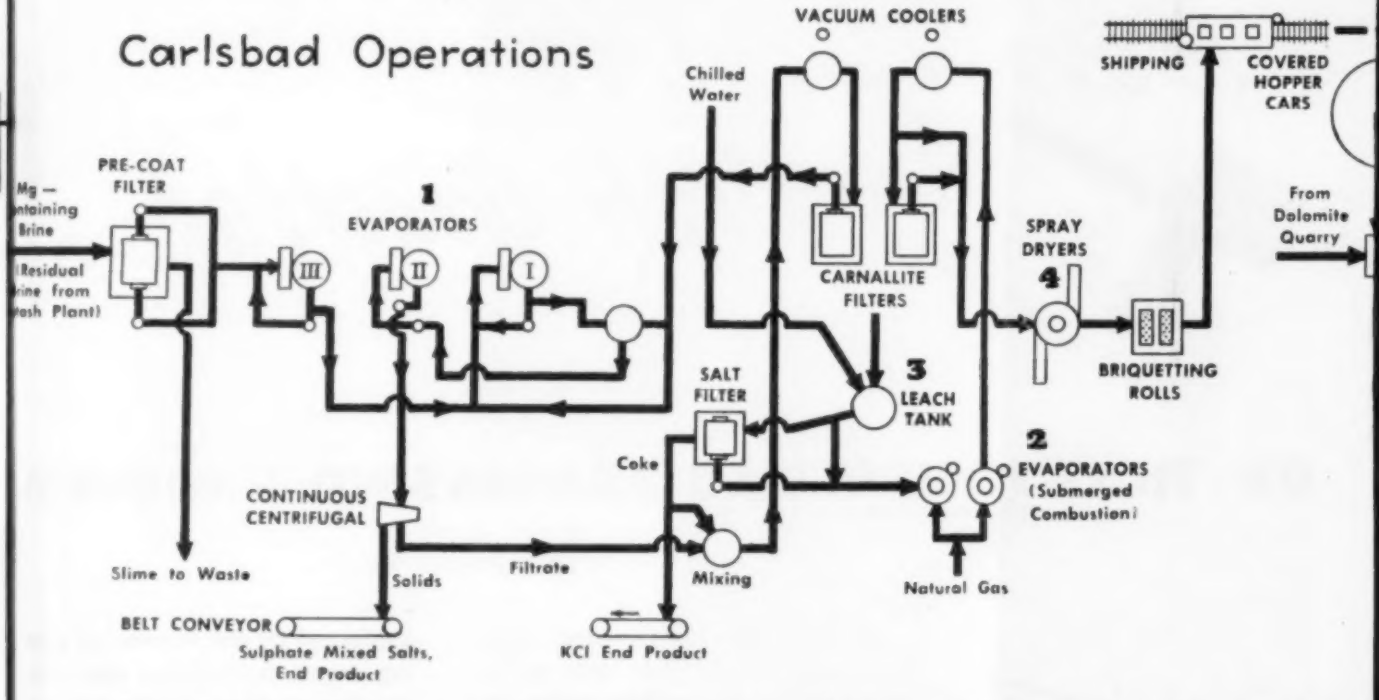
May, 1944

PAGES 142 to 145

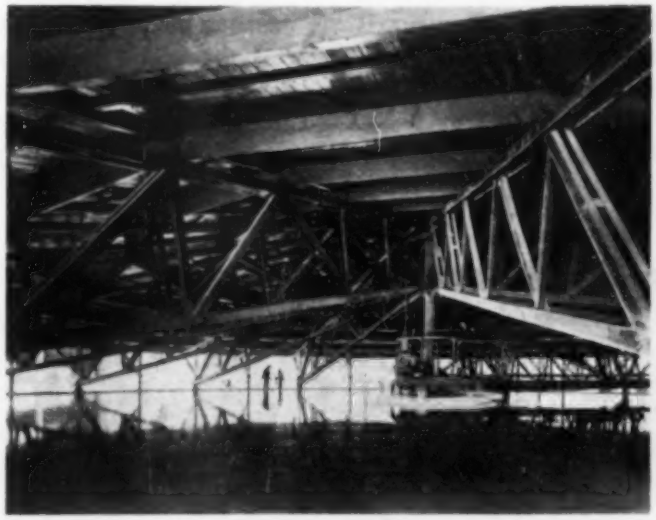


3 Potassium sulphate is removed from solution by reaction and precipitation in brick-lined processing tanks

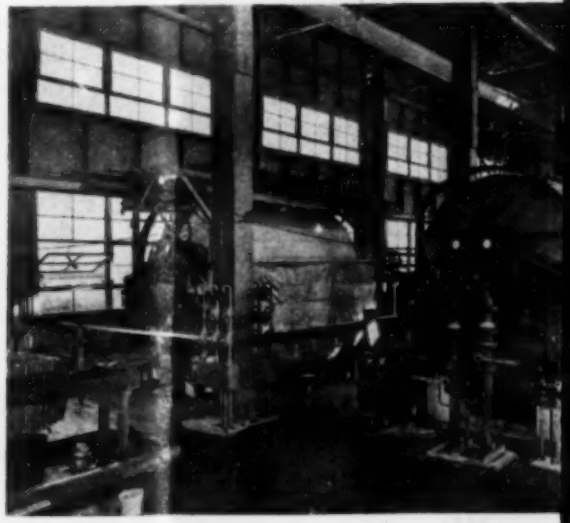
4 Water is cooled by means of a large wood
culated for processing. Power is generated in



8 Removal of calcium carbonate from the magnesium chloride is partially effected in Dorr thickeners



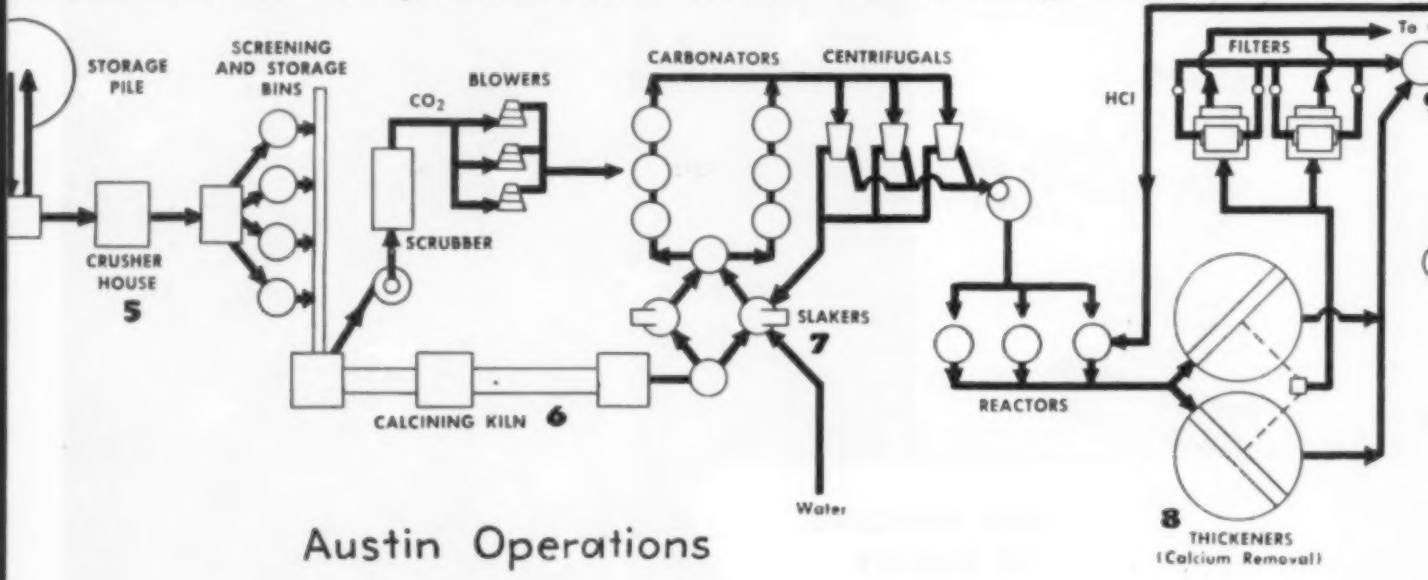
9 Filtration of magnesium chloride solution for com
cium carbonate is accomplished by the use of vacuum



en cooling tower and recir-
the central station at right

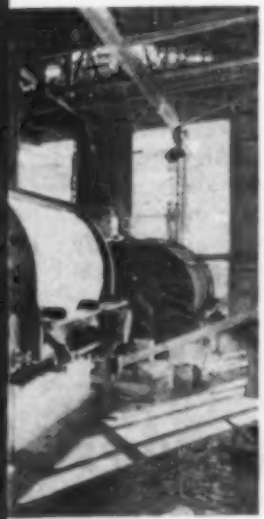
5 Dolomite from the quarry at Austin is transported by conveyor to the crusher house and then to storage bins

6 After crushing and sizing
passes from storage bins to

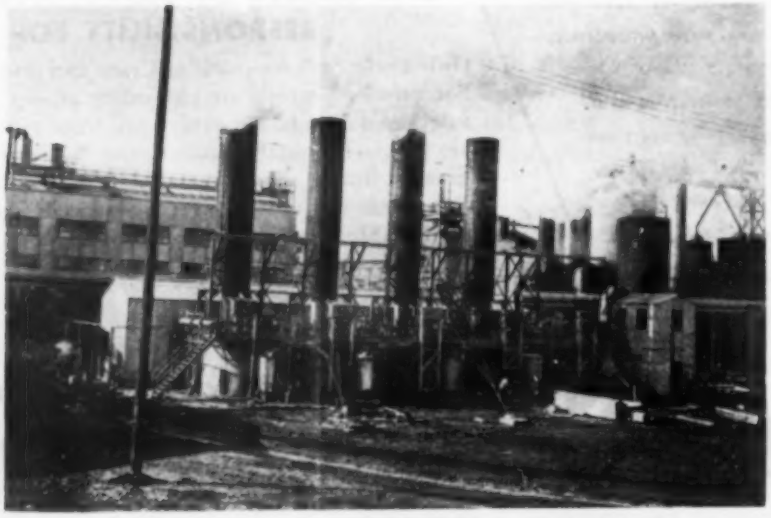


Austin Operations

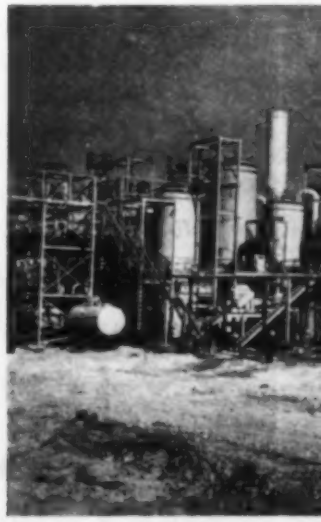
plete removal of cal-
filters in foreground



10 Concentration of the magnesium chloride solution before drying, takes place in Ozark submerged combustion evaporators

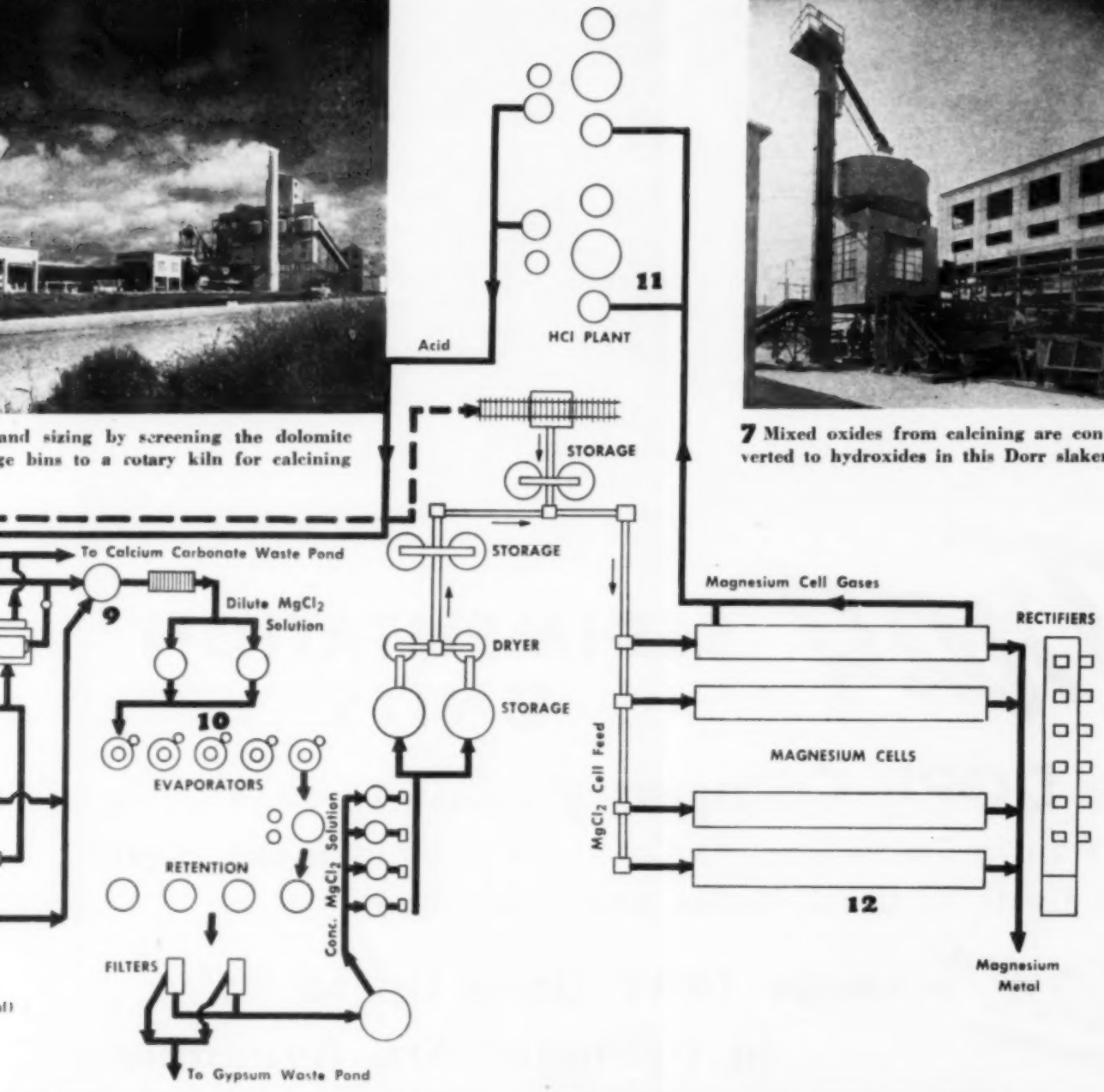


11 Chlorine liberated from
chloric acid and used for gen



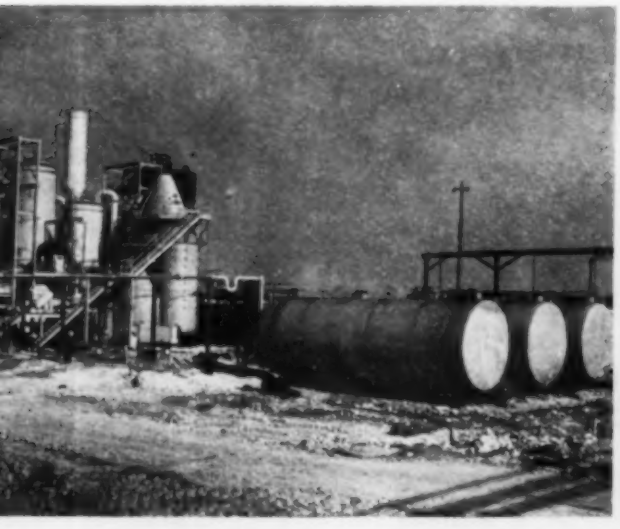
and sizing by screening the dolomite
ge bins to a rotary kiln for calcining

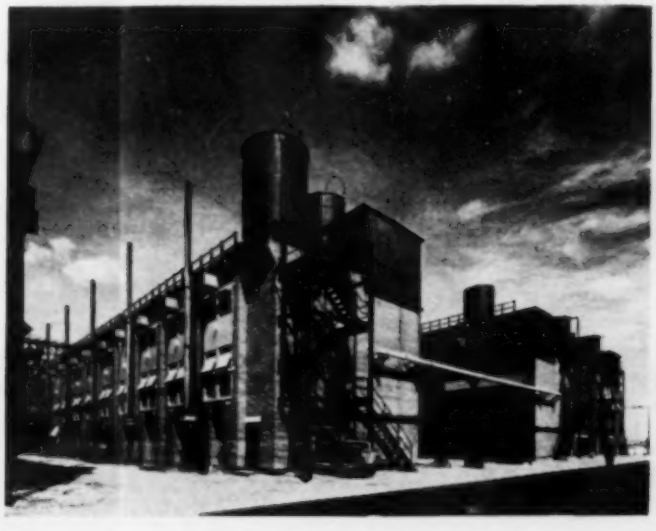
7 Mixed oxides from calcining are converted to hydroxides in this Dorr slaker

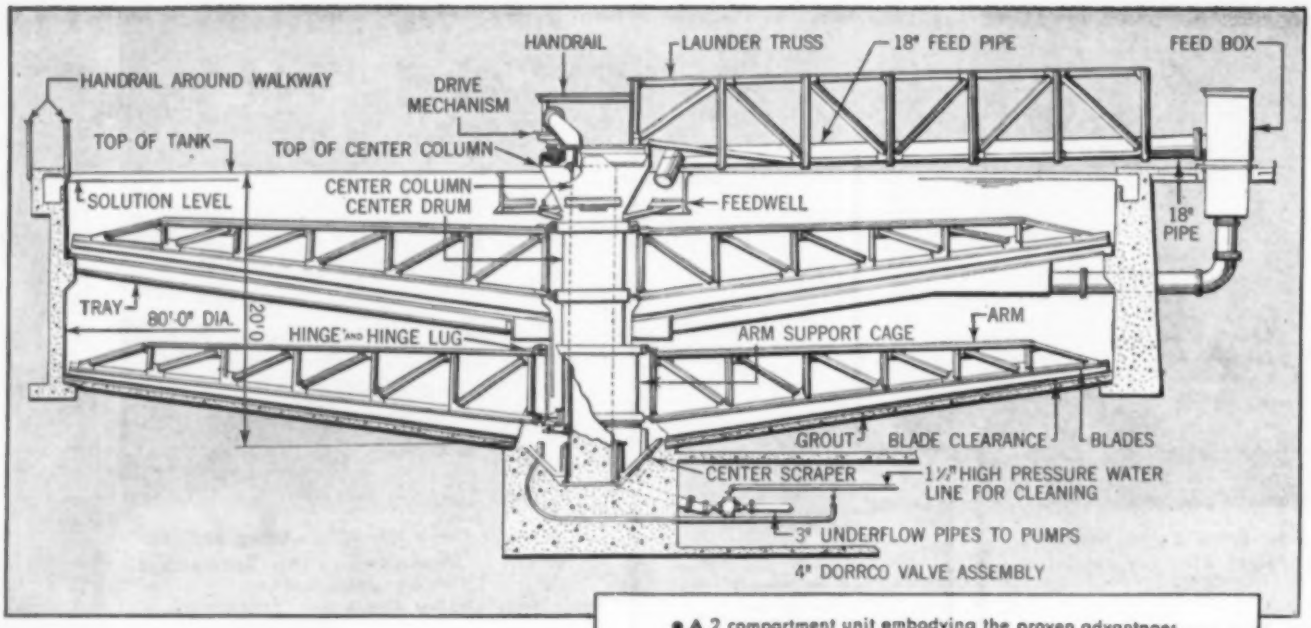


ted from magnesium cells is converted into hydro-
sed for generating additional magnesium chloride

12 Electrolysis of fused magnesium chloride to magnesium metal occurs in these brick cell houses







• A 2 compartment unit embodying the proven advantages of the centerpier construction and rugged Central Drive.

Tray SEDIMENTATION UNITS

The DORR Company Pioneered TRAY Units Years Ago in Small Sizes to Conserve Ground Space, Heat Losses, Costs of Construction and Operation.

Now— Large TRAY Units Up to 95′ in Diameter Are Available

• One 80′ TRAY unit possessing the same capacity as two 80′ single units or four 40′ TRAY units comprises only one foundation, one drive mechanism, one pump—obvious savings.

• Send a statement of your sedimentation problem to our nearest office or ask a Dorr Engineer to call at your convenience—no obligation, of course.

DORRCO

THE DORR COMPANY, ENGINEERS

NEW YORK 22, N. Y. . . 570 LEXINGTON AVE.
ATLANTA 3, GA. . . . WILLIAM-OLIVER BLDG.
TORONTO 1, ONT. . . . 80 RICHMOND ST. W.
CHICAGO 1, ILL. . . . . 221 NO. LA SALLE ST.
DENVER 2, COLO. . . . . COOPER BUILDING
LOS ANGELES 14, CAL. . . . 811 WEST 7TH ST.

RESEARCH AND TESTING LABORATORIES
WESTPORT, CONN.

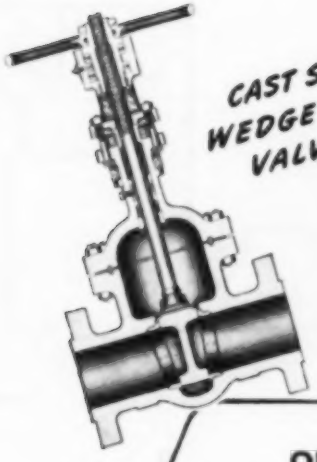
SUGAR PROCESSING
PETREE & DORR DIVISION
570 LEXINGTON AVE., NEW YORK 22

RESEARCH ENGINEERING **DORR** EQUIPMENT

ADDRESS ALL INQUIRIES TO OUR NEAREST OFFICE

Power or Process Piping Systems CRANE can equip them 100%

Pipe
Pipe Bends, Flanged and Welded
Automatic Stop Check Valves
Pipe Supports
Gaskets and Studs
Gate Valves
Globe Valves
Flanges
Reducers
Screwed Fittings
Flanged Fittings
Welding Fittings
Fabricated Piping
Separators
Gauges
Safety Valves
Steam Traps
Unions
Union Fittings



CAST STEEL WEDGE GATE VALVES

Steam Piping for Double-Boiler Hook-up

ONE STANDARD OF QUALITY

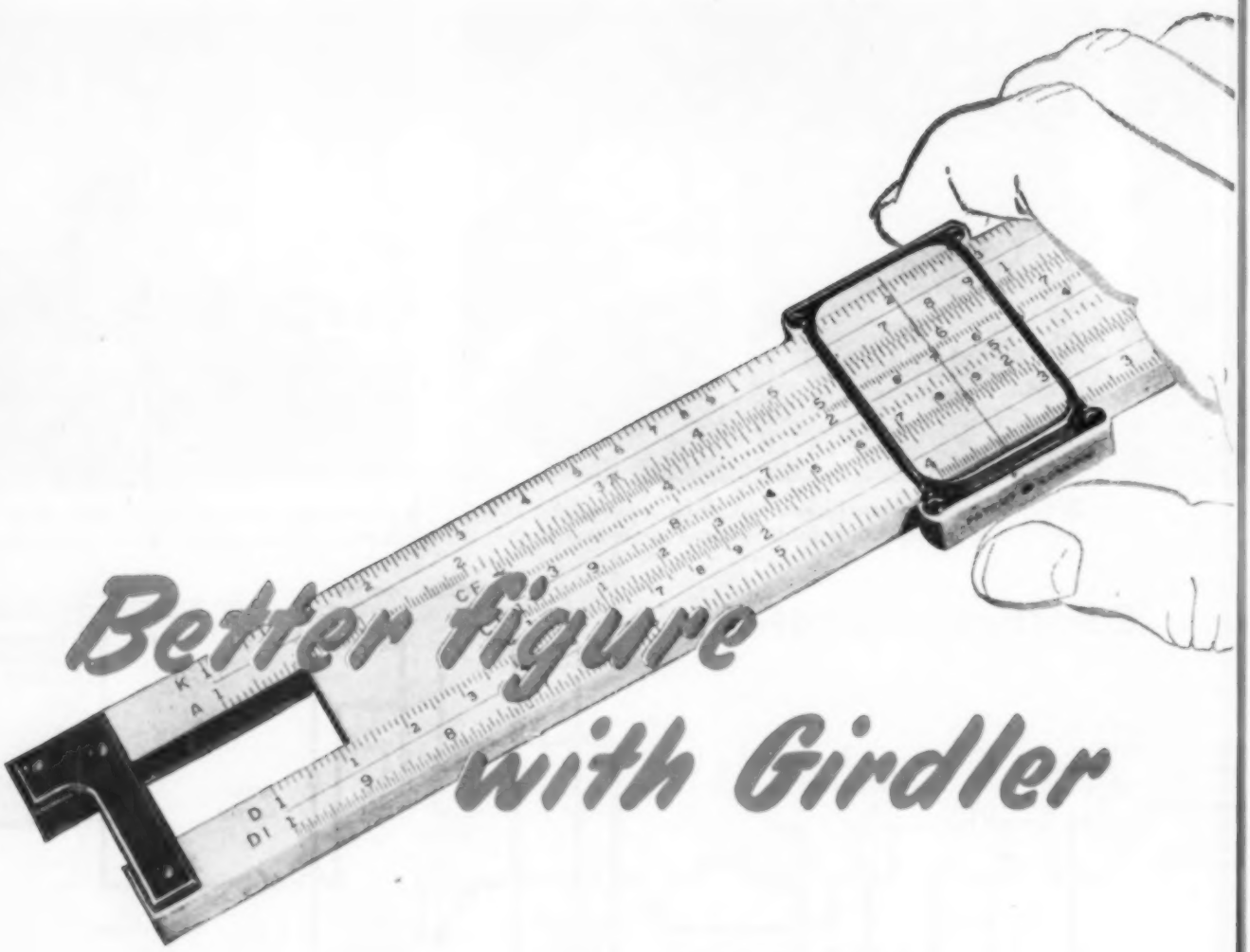
The whole system is more dependable because there's one high standard of quality—adequate for the need—in every part. In Crane Steel Gate Valves, for example: Straight-through ports minimize turbulence, erosion, resistance to flow. Strong tee-head disc-stem connection, ball-bearing yoke, and non-corrosive stem bearings assure smoothest operation. Adequate stem power and extra long disc guides make seating positive.

ONE SOURCE OF SUPPLY . . . ONE RESPONSIBILITY FOR ALL MATERIALS

Only a source as complete as Crane can give you these advantages. For power, process, or any other piping system—not only the valves and fittings, but every part, from pipe to gaskets and studs, are regularly available from Crane. Where else, but in the world's greatest line of piping materials, could you expect a selection of equipment that always meets your needs—of quality that's always dependable? For, back of it stands Crane Co.'s 89-year leadership in the piping field. CRANE CO., General Offices: 836 S. Michigan Ave., Chicago 5, Ill.

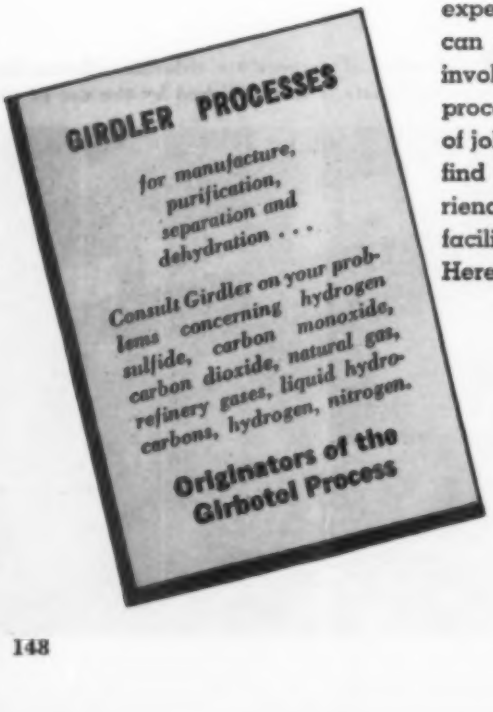
CRANE

VALVES • FITTINGS • PIPE
PLUMBING • HEATING • PUMPS



Better figure with Girdler

ON THAT *TOUGH* GAS PROCESSING PROBLEM


GIRDLER PROCESSES
for manufacture, purification, separation and dehydration . . .
Consult Girdler on your problems concerning hydrogen sulfide, carbon monoxide, carbon dioxide, natural gas, refinery gases, liquid hydrocarbons, hydrogen, nitrogen.
Originators of the Girbotol Process

A slide rule helps — but *only* experience, facilities and ability can solve the intricate difficulties involved in a *really tough* gas processing problem. *That* type of job suits GIRDLER! Here you'll find an engineering staff of experienced specialists — and splendid facilities for development work. Here, too, is pioneer thinking — implanted by the success of solving many engineering and construction problems in the gas processing field.

Inquiries concerning gases, gaseous mixtures or liquid hydrocarbons receive prompt and experienced attention. So — when such problems arise in your organization — better figure with GIRDLER!

The GIRDLER CORPORATION
Gas Processes Division · Louisville 1, Ky.

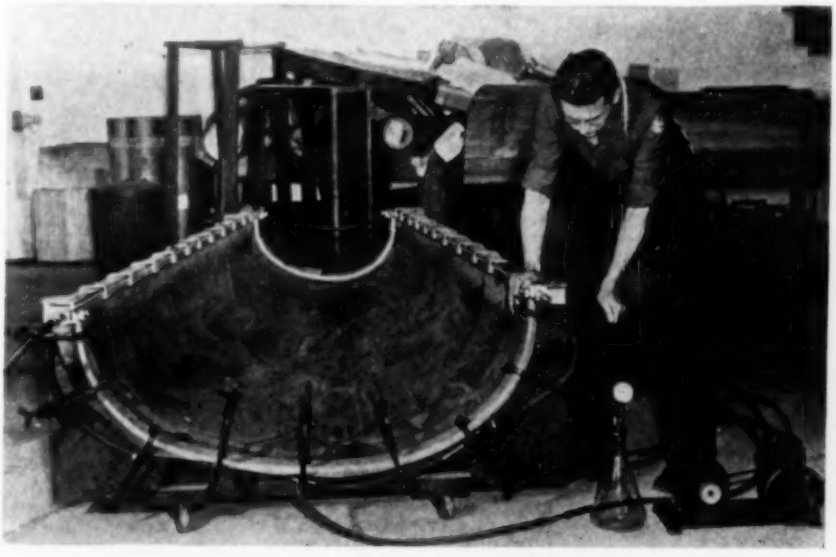
CHEMICAL ENGINEERS AND CONSTRUCTORS

NEW PRODUCTS AND MATERIALS

JAMES A. LEE, Managing Editor

CONTENTS

Structural Materials 149
Synthetic Rubber 149
Synthetic Resin 149
Protective Coatings 150
Paint Brush Restorer 150
Plasticizer 150
Carbon Remover 150
Synthetic Rubber Softener 152
Toxic Agent for Insecticides 152
Chlorinated Paraffins 152
Lacquer Protective Coating 154
Anhydrous "Hypo" 154
Ink for Glass and Porcelain 154
Corn Borer Killer 154
Gasoline Stretcher 155
Rubber Plasticizer 155
Hydroxyethyl Cellulose 155
Coatings 156
Synthetic Rubber–Resin 156
Glass–Asbestos Textile 157
High-Boiling Hydrocarbon 157
Rubber Accelerators 157
Rubber from Lactic Acid 158
Styrene Dibromide 158
Vulcanizing Agent 158
Sealing Tapes 159
Rubber Plasticizer 159
Fire-Resistant Material 160
Thiocyanate Insecticide 160



On strength-weight basis glass-reinforced fuselage shown here is 50 percent stronger than metal and 80 stronger than wooden now in service

STRUCTURAL MATERIALS

SUCCESSFUL flight tests of a training plane equipped with a glass-reinforced plastic fuselage, side panels, and tail cone, have culminated a research program initiated by the Army Air Forces Material Command and aimed at developing high-strength plastic structural materials for use in aircraft construction.

Experimental plastic fuselage is of sandwich construction. The sandwich consists of a balsa wood core between an inner and outer skin of plastic reinforced with fibrous glass cloth. Ground destruction tests of three fuselages of the same design, of glass-reinforced plastic, metal, and plywood, indicate that for equivalent weight the glass sandwich fuselage is considerably the strongest. On a strength-weight basis the glass-reinforced fuselage is 50 percent stronger than the metal fuselage and 80 percent stronger than the wooden now in service.

Firing tests have indicated that the glass-reinforced fuselage would be satisfactory under gunfire. The material did not flower and high explosive projectiles failed to detonate because of the low density of the material. The glass reinforcements employed in fabricating the laminates were heat-treated Fiberglas cloths and short, fine fibers known as Fiberglas flock. The resins were Plaskon 900, Laminac P-4122, MR-1A, Monsanto 38691, CR-39, CR-39Bd, and CR-149.

Each of the various combinations of glass and resin was fabricated into one-quarter and one-half inch thick laminated sheets. Tensile strengths were found to be proportional to the amount of glass present in the laminates and varied from 43,360 to 54,720 lb. per sq.in. Compression strengths as high as 56,820 lb. per sq.in. were obtained. Flexural values ranged between 45,350 and 84,600 lb. per sq.in. Impact strengths of unnotched specimens were from 28.82 to 31.25 foot pounds. Modulus of elasticity was 2,200,000 lb. per sq.in. Average specific gravity was 1.75. These values are for cross-laminated glass cloth. Strength values approximately twice as high may be obtained with parallel-laminated cloth.

HEAT-RESISTANT RUBBER

A NEW TYPE of synthetic rubber, unique because it promises to be especially suitable for use in making heavy-duty tires for trucks, buses and even military vehicles, has been developed by the research department of The Mathieson Alkali Works, New York, N. Y., it was revealed by G. W. Dolan, president of the company. The new rubber is strong, tough and resistant to cuts and abrasion. But its outstanding characteristic is that, unlike GR-S, the Mathieson rubber withstands elevated temperatures. Preliminary reports of comparative road tests under the sponsorship of the Office of Rubber Director indicate that this new rubber stands up well under severe service conditions.

Reports show that the Mathieson rubber has greater resistance to heat, moisture, oil and kerosene than GR-S, and less permeability to gases. In certain of these respects, the laboratory tests indicate superiority to natural rubber as well. It has good milling properties.

This rubber is made of butadiene and a new chemical produced from readily available raw materials. Its cost is expected to be about the same as that for GR-S on the same scale of manufacture. It is still in the development stage.

SYNTHETIC RESIN

A RESIN, Duralon, a furane derivative, has recently been announced by the United States Stoneware Co., Akron, Ohio. It is characteristized by the lowest water absorption of any organic resin, insolubility (after activation) in any solvent or combination of solvents, high electrical resistivity, absolute stability in storage and handling, and by ease of workability. In its pure form it is a heavy, viscous liquid, dark maroon in color. On incorporation of catalysts and application of mild heat, Duralon reverts to an extremely hard, dense black substance. Varying physical, chemical and electrical properties can be developed in the base resin by incorporation of the usual fillers and lubricants. In certain stages Duralon can be readily machined by drilling, milling, turning, sand-

MONSANTO

PHENOL

U. S. P.

purity

means quality in finished products

Monsanto Phenol, U.S.P., manufactured under strictest plant control and constantly checked by laboratory technicians, is a superior product. This contributes to the quality of the products in which Monsanto Phenol is used.

Significant, from the standpoint of purity, is Monsanto Phenol's crystallizing point of 40.6°C. Minimum.

Phenol sales all are under government allocations at present. We are prepared to give you the best service possible within these necessary restrictions. We shall be pleased to give you data on phenol and its applications at any time. MONSANTO CHEMICAL COMPANY, Organic Chemicals Division, 1700 South Second Street, St. Louis 4, Missouri. District Offices: New York, Chicago, Boston, Detroit, Charlotte, Birmingham, Los Angeles, San Francisco, Montreal, Toronto.

If your organization uses phenol, you will find this booklet on safe handling of phenol worthy of study. A copy will be sent you free upon request.

MONSANTO CHEMICALS

SERVING INDUSTRY...WHICH SERVES MANKIND

ing, grinding, etc. These resins are readily soluble before activation, in many inexpensive hydrocarbons, as well as in ketones and chlorinated solvents. While preliminary studies indicate that Duralon possesses definite molding possibilities, its paramount immediate importance is as an impregnant, as a laminating and bonding agent, or as a protective coating material. It is in these applications that its resistance to moisture, its insolubility in solvents (even at elevated temperatures), its versatile surface characteristics (ranging from a high gloss to a crinkle finish), prove highly essential in solving many present day problems. Many of these properties can be attributed to the unusual wettability of the unconverted resin. Duralon solutions may be applied as coatings by any of the conventional processes or may be used for impregnation of porous materials, or as a bonding agent.

PROTECTIVE COATINGS

SAID to be a practical alternate for phthalic alkyd, Aroplaz 1306 is manufactured by a new process developed by U. S. Industrial Chemicals, Inc., New York, N. Y. It may be used for all types of interior architectural and industrial coatings, both white and colored. In water and alkali resistance and in flexibility Aroplaz 1306 compares favorably with modified phenolic and maleic resins and oil combinations. Initially very pale, the staining properties are so slight that white enamels can be made approaching the whiteness obtained with alkyds. Color retention is similar to maleic resin and oil combinations. In gloss and gloss retention it is superior, in both clear and pigmented films, to many alkyds. It is available for prompt shipment without restriction.

Non-volatile	75% by weight
Solvent	25% by weight (mineral spirits)
Acid number: (solid resin)	10-20
Color: (75% solids solution)	7-9 (G-H 1933)
Viscosity: (75% solids solution)	Y-Z1
Viscosity: (when thinned further to 50% solids with mineral spirits)	E-F
Weight per gallon:	7.9 lb. (at 20 deg. C.)
Reportable oil content:	66% by weight of non-volatile

PAINT BRUSH RESTORER

PAINT BRUSHES may be cleaned, softened and reclaimed by a solution developed by Technical Development Laboratories, Tenafly, N. J. Recently used brushes are said to become clean in a few hours while old ones in from 12 to 96 hr. The solution is non-flammable and does not give off poisonous fumes.

PLASTICIZER

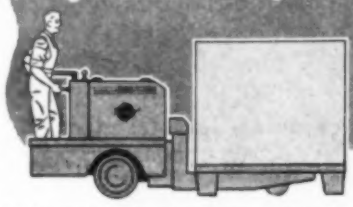
FROM MIDLAND, Mich., comes an announcement of the development of a new product, propylene glycol N.F. which has been developed by Dow Chemical Co. It was designed for use as a plasticizer and chemical intermediate for food processing. It can be used in cosmetic and pharmaceutical manufacture because of its diversified solvency and preservative properties.

CARBON REMOVER

PLASTIC PELLETS of Tenite 1 are used in sandblasting equipment to remove carbon from piston walls and the narrow piston ring grooves, by the U. S. Army

IS YOUR PROBLEM ONE OF

Speeding Carloading or Unloading?



Industrial Trucks have revolutionized carloading and unloading methods. Our files contain hundreds of case histories in which Baker Trucks have reduced time, cost and manpower on these operations to a fraction of former requirements. A few typical installations are described below.

★ ★ ★

Baker Low Lift Trucks load and unload forged parts, castings and other materials on skids—eliminating individual handling of pieces. In many cases shipment is made on skids, enabling trucks to also save time at receiving end. Illustration shows skid-load of zinc pigs being loaded into a box car.

Equipped with telescoping uprights a Baker Hy-Lift Truck can enter a box-car door with ease, and tier material inside the car, conserving shipping space. (See illustration). Actual savings in costs of loading and unloading operations with Baker Trucks have been reported as high as 75% over former methods.

Where material lends itself to shipment on wooden pallets, Baker Fork Trucks can greatly reduce time and cost of loading and unloading. One Company reports savings of 25c per ton, or $12.50 per car—at the same time releasing seven men for other work. This procedure is called "Unit Handling."*

Baker Crane Trucks have solved many difficult loading problems, where heavy, bulky parts or materials are to be shipped on gondola or flat cars. Illustration shows a crane truck with a large hook making quick work of loading heavy coils of wire at a wire mill.

A large aircraft manufacturer uses Baker Hy-Lift Trucks to unload crated airplane engines weighing 2100 pounds from the boxcar in which they are shipped. One operator with a truck transports the engines either to storage, or to the assembly line—relieving a number of men for other duties.

Highway-truck loading with Baker Fork or Hy-Lift Truck requires no loading platform. Sacks of bulk materials may be handled or shipped on pallets, eliminating the need for individual handling, and permitting tiering of material in warehouse or carrier.

** A bulletin "Unit Loads—Their Handling, Shipment and Storage" has just been published by the Industrial Truck Statistical Association. A copy will be mailed upon request.*

WRITE FOR YOUR COPY

Plant and production managers, traffic managers, superintendents, purchasing agents and any others concerned with material handling will find the new Baker Catalog No. 52 a valuable reference.

BAKER INDUSTRIAL TRUCK DIVISION

of The Baker-Raulang Company

2146 WEST 25th STREET • CLEVELAND, OHIO

In Canada: Railway and Power Engineering Corporation, Ltd.

Baker INDUSTRIAL TRUCKS

These Alloy Rabble Arms Do Not Grow or Scale; *Blades Are Easy to Replace*

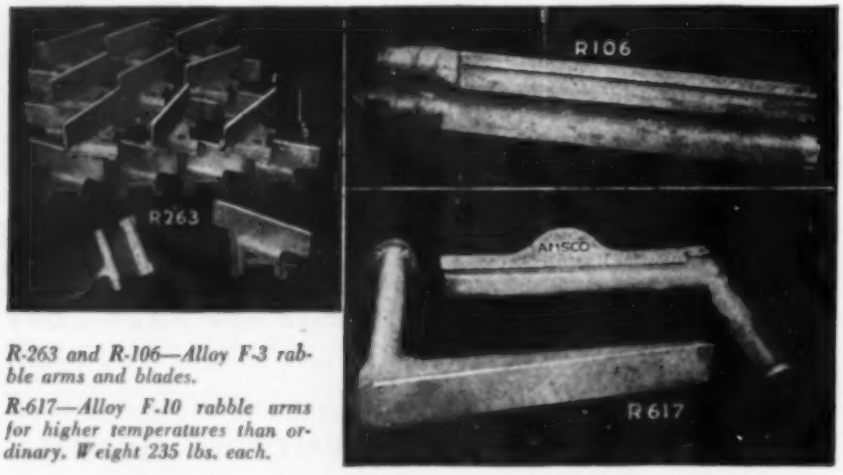
The various processes carried on in modern multiple-hearth roasting, calcining and drying furnaces call for the continuous application of heat and the stirring or "rabbling" of the material. The rabble arms and blades used for the stirring operation are exposed to temperatures which are not excessively high, ranging from 900° to 1800° F., but they are higher than ordinary iron will resist over long periods. Too, corrosion arising from sulphurous gases and severe abrasion have a very destructive effect on anything but a properly selected chromium-nickel alloy.

Amsco Alloy F-3, containing 27 to 29% chromium and 0 to 3% nickel, is almost universally economical in roasting practice. Some rabble arms are cooled by the air which is passed through them, not primarily for cooling purposes but for preheating purposes. It is not necessary to cool Amsco Alloy rabble arms, and the useful service life of non-cooled Amsco arms is no less than that of those which are cooled.

Where temperatures are on the high side and greater strength is required to prevent sagging, arms of Amsco Alloy F-10 (26-28% chromium and 10-12% nickel) are recommended. At a zinc-roasting operation a decided improvement was effected by this change in analysis.

It is seldom reported that an Amsco Alloy rabble arm, blade or tooth has broken in operation; and the service life despite heat, corrosion and abrasion is usually many times that of cast iron. Because this chromium-nickel alloy does not "grow" in service, the rabble blades not only last longer but are easier to replace, cutting down delays and labor costs.

Ask for Bulletin 108.



R-263 and R-106—Alloy F-3 rabble arms and blades.

R-617—Alloy F-10 rabble arms for higher temperatures than ordinary. Weight 235 lbs. each.

Advantages of Amsco-Nagle Centrifugal Pumps described in Bulletin 940.

Amsco
AMERICAN MANGANESE STEEL DIVISION
Chicago Heights, Illinois
FOUNDRIES AT CHICAGO HEIGHTS, ILL.; NEW CASTLE, DEL.; DENVER, COLO.; OAKLAND, CALIF.; LOS ANGELES, CALIF.; ST. LOUIS, MO.
OFFICES IN PRINCIPAL CITIES

AMERICAN Brake Shoe COMPANY

Air Forces. Tenite in granulated form of 0.063 in. with an intermixture of smaller sizes is prepared by Tennessee Eastman Corp., Kingsport, Tenn. The pellets resemble those regularly supplied to the molding industry except that they are considerably smaller. When pellets are blown against the piston sides and piston ring grooves, the carbon is knocked off by force and the surface is given a polish without abrasion of the metal and without pulverizing the pellets.

SYNTHETIC RUBBER SOFTENER

A SOFTENER for GR S synthetic rubber, especially designed to yield a stock with good processing properties, flat curing characteristics, and snappy, high modulus, high tensile vulcanizates, is offered by the C. P. Hall Co., Akron, Ohio. Para Lene is a blend of petroleum hydrocarbons. Its viscosity is low enough that it may be handled as a liquid in the factory. Tentative specifications are given below:

Acid number	Less than 20
Iodine number	Less than 20
Percent ash	Less than 0.5
Percent insoluble in acetone	Less than 1.0
Viscosity (Saybolt Universal at 210 deg. F.)	230 ± 40
Flash point	Above 350 deg. F.
Pour point	Below 70 deg. F.
Specific gravity	1.00 ± .05

TOXIC AGENT FOR INSECTICIDES

To INSECTICIDE manufacturers interested in obtaining better performance at lower cost, Hercules Powder Co., Wilmington, Del., presents Thanite, a toxic agent for household and livestock sprays and insecticide preparations. High knock-down and kill, and longer lasting repellency are said to be assured at lower concentrations—in safe, low cost, non staining sprays which impart no residual odor or taste to foods. Of special interest to manufacturers is its unusual stability. Thanite sprays can be carried in stock from one season to the next without losing any strength—unlike pyrethreum sprays which stored over a period of 12 months frequently lose as much as 50 percent of their toxic effectiveness.

CHLORINATED PARAFFINS

CHLORINATED paraffins range from liquid to brittle resins depending upon the percentage of combined chlorine. The Amecco Chemicals, Inc., Rochester, N. Y. are offering a 43 percent chlorinated paraffin, Paroil 143; a 60 percent product, Paroil 163; and a 70 percent resin, Paroil 173. The 43 percent product is a non-volatile, honey-colored or amber liquid with viscosity around 25 poises at 25 deg. C. and a specific gravity of about 1.1. It is non-flammable and weighs about 9.75 lb. per gal. It is soluble in aliphatic and aromatic hydrocarbons, esters, ketones, chlorinated solvents, ethers and in butanol and higher alcohols.

The 60 percent chlorinated paraffin is a soft amber colored resin with a softening point around 50 deg. C. It has a specific gravity of about 1.36. It is only slightly soluble in straight aliphatic hydrocarbons but dissolves in high solvency naphtha and in all the other solvents which can be used with the 43 percent product.

The 70 percent chlorinated paraffin resin is a hard brittle amber colored ma-

Announcing

an important new grouping of process equipment manufacturers, each outstanding in its specialized field, now welded together to serve you with one organization, one responsibility, one standard of performance—

GENERAL AMERICAN PROCESS EQUIPMENT DIVISION
GATX
GENERAL AMERICAN

GENERAL AMERICAN PROCESS EQUIPMENT

A Division of

GENERAL AMERICAN TRANSPORTATION CORPORATION

Composed of:

LOUISVILLE DRYING MACHINERY CO.
(Rotary Dryers & Presses)

THE TURBO-MIXER CORPORATION
(Mixers & Agitators)

THE CONKEY COMPANY
(Filters & Evaporators)

AMERICAN MACHINE COMPANY
(Drum Dryers)

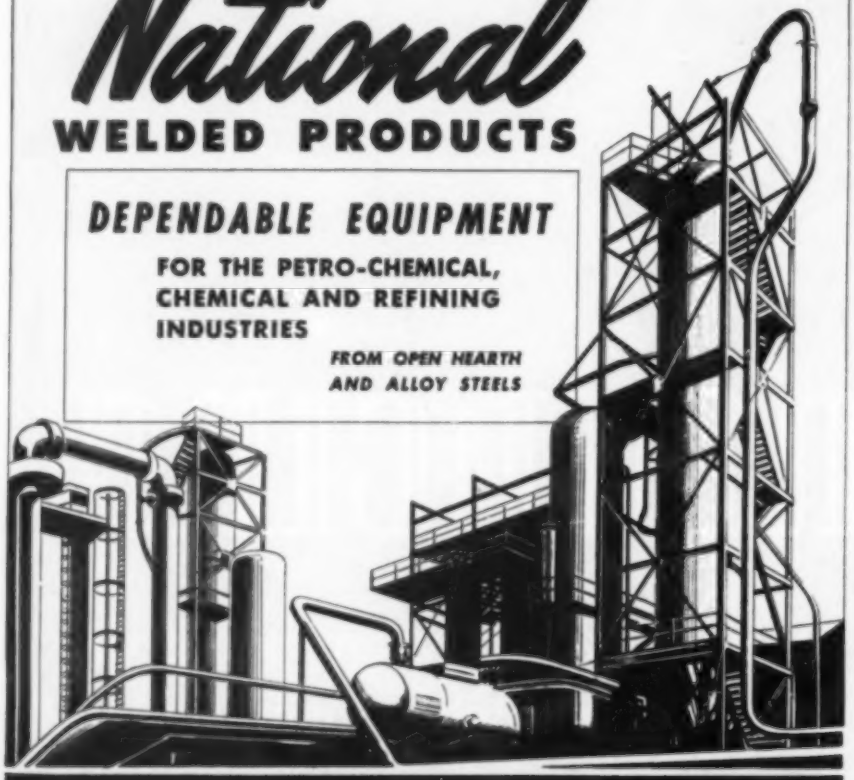
Associated with: PLATE AND WELDING DIVISION *(Tanks and Pressure Vessels)*

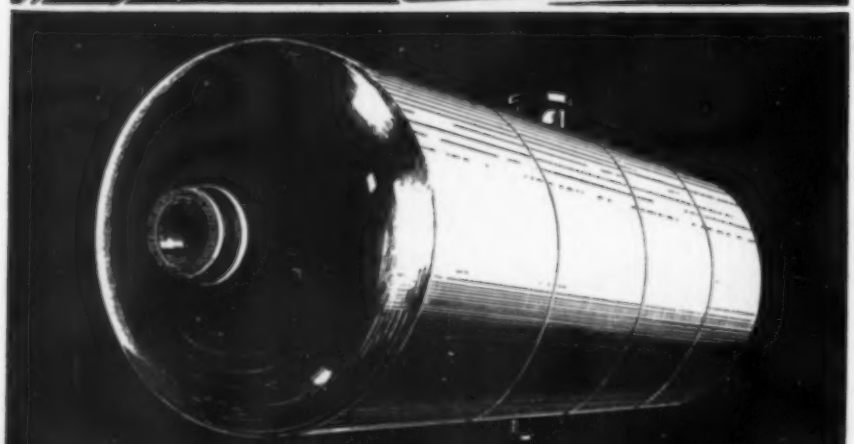
OFFICES: 451 BAXTER AVENUE, LOUISVILLE 4, KENTUCKY

NEW YORK . . . CHICAGO . . . SHARON, PA.

National
WELDED PRODUCTS

DEPENDABLE EQUIPMENT
FOR THE PETRO-CHEMICAL, CHEMICAL AND REFINING INDUSTRIES
FROM OPEN HEARTH AND ALLOY STEELS





"National" offers unexcelled facilities for building pressure vessels, condensers, towers, autoclaves, exchangers and processing tanks.
Production available NOW—our engineers are at your service.

National
ANNEALING BOX COMPANY
API-ASME Codes • Stress Relieving • X-ray
Pledged to Quality Since 1895
WASHINGTON, PENNA.

terial with a softening point over 80 deg. C. Some grades have a softening point slightly over 100 deg. C. This material is insoluble in aliphatic hydrocarbons and in the lower alcohols but dissolves in high solvency naphthas, aromatic hydrocarbons, esters, ketones, chlorinated solvents and turpentine. It is compatible with a wide variety of resins used in protecting coatings, including most of the types of alkyds, phenolics, acrylic, urea and melamine-formaldehyde resins.

LACQUER PROTECTIVE COATING

COMMUNICATIONS equipment that soon became useless in tropical climates is now being protected from high humidity and fungus growth by a new lacquer, developed by Maas & Waldstein Co., Newark, N. J. At the request of the Signal Corps the company developed a lacquer that is moisture-resistant, has high dielectric strength and retards the growth of fungi. It is now being used on signal and other communication equipment at our tropical bases. The new lacquer marketed as Dulac Fungus-Resistant Lacquer No. 86 may be used to treat communications equipment before it is assembled and shipped to the tropics. It is a clear, quick-drying lacquer that may be applied by spraying, brushing or dipping.

ANHYDROUS "HYPO"

RECENTLY commercial production began on anhydrous sodium thiosulphate by A. R. Maas Chemical Co., of South Gate, Calif. This chemical which is by no means new to chemists has never received much attention. The photo trade has always been satisfied with the standard crystal "hypo" which is the hydrated form. Present interest is due to the discovery by customers that half the packaging, half the volume and one-third of the freight may be saved by changing to the anhydrous form. All who are in touch with the war effort know the extreme pressure that is being put on producers to save these three precious things. The ability of the anhydrous form to resist any temperature seems to fit it specially for tropical use.

INK FOR GLASS AND PORCELAIN

NEWEST product to be formulated by Stewart Research Laboratory, Franconia, Alexandria, Va., is Glink, a permanent ink for writing on glass, porcelain and other ceramics. It is said to be non-corrosive, non-poisonous and non-flammable. Mixed with glycerin it can be used to ink a pad for rubber stamps.

CORN BORER KILLER

A SALT-LIKE plant food substance that is now functioning successfully on an experimental basis may prove an effective weapon against the corn borer and thus increase the food supply. The material now being tested is an inexpensive chemical combination which is mixed with fertilizer and spread on the ground to be taken up into the plant tissues. The mixture does not kill larvae but renders corn stalks so distasteful that the larvae forsake the cornfield for untreated feeding areas. Fortunately, neither the taste nor the wholesomeness of the corn for human beings and animals is affected.

The compound was developed by John Bell, agronomist for Darling & Co., Chicago, Ill. He estimates that the substance which remains a closely guarded secret pending patent proceedings will increase the cost of fertilizing land for hybrid corn only 25 to 30c. an acre, which is not prohibitive.

GASOLINE STRETCHER

ADDITIVES claimed to increase gasoline mileage have increased in public attention at regular intervals. At Medina, N. Y., the Motor Fuel Corp. has developed Powerine. One gallon added to four gallons of gasoline, it is said, steps up mileage per gallon from 14 percent to 25 percent.

RUBBER PLASTICIZER

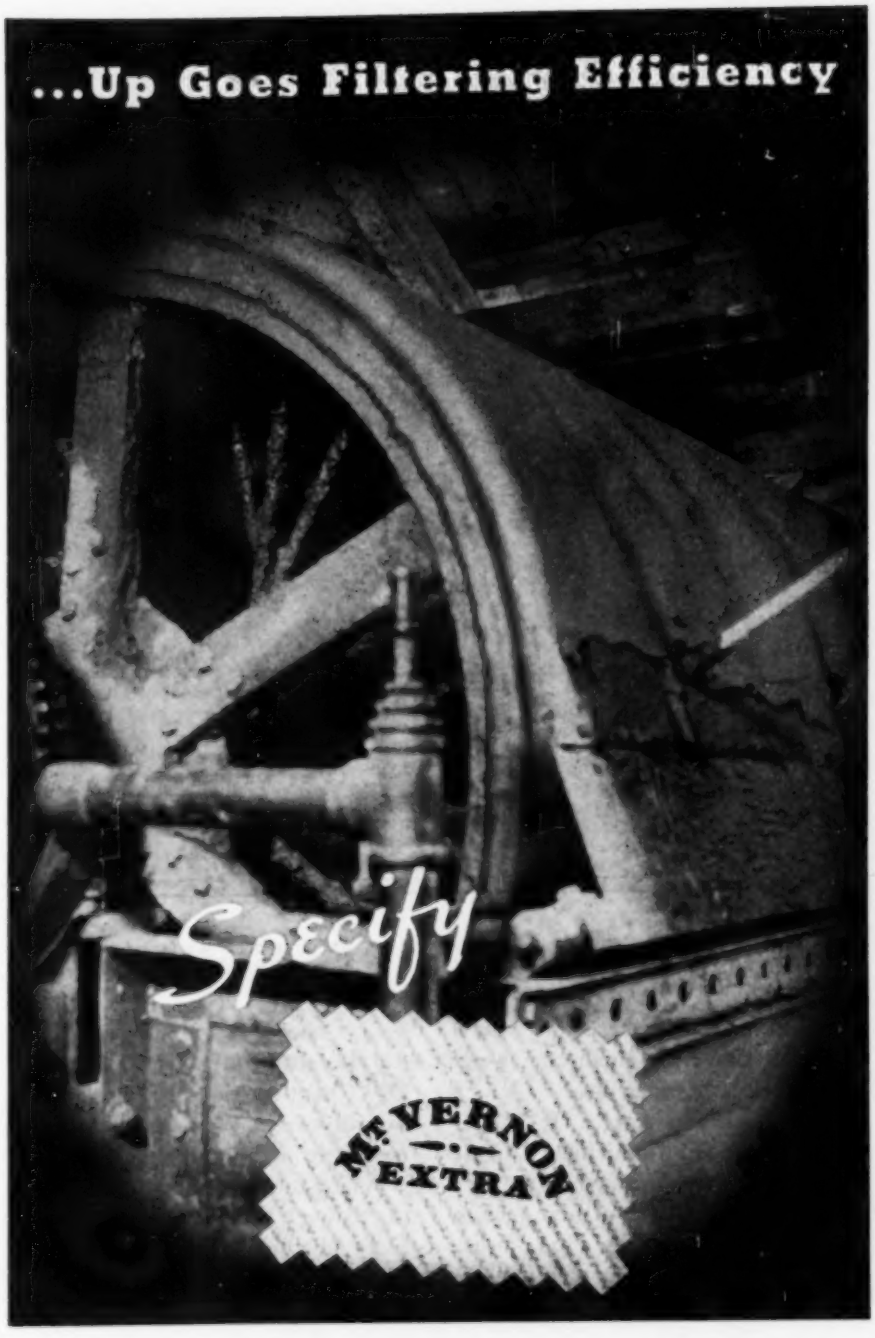
FROM TRENTON, N. J., comes the announcement of TP-90-B, a new high-boiling organic liquid plasticizer developed by Thiokol Corp. which promises to hold an important role in giving excellent low-temperature characteristics to butaprene, chemigum, hycar, neoprene, perbunan and other synthetic rubber and plastic stocks. Straw to brown in color and with a butter-like odor, TP-90-B is completely miscible with alcohols, aromatic hydrocarbons, aliphatic hydrocarbons, ketones, ethers and chlorinated hydrocarbons. It is insoluble in glycerine, glycols and water. Some pertinent facts about TP-90-B are given below:

Boiling point	330 to 360 deg. C. at 760 mm 198 to 210 deg. C. at 4 mm
Freezing point	—32 deg. C.
Specific gravity	0.97/15 deg. C.
Lb. per gal.	8.09
Refractive index	1.438/15 deg. C.
Solubility in water	Less than 1%

HYDROXYETHYL CELLULOSE

AN AQUEOUS solution containing 10 percent of hydroxyethyl cellulose is offered by Carbide and Carbon Chemicals Corp. as Cellulose Hydroxyethyl Cellulose WS. On drying it produces an almost colorless, nearly transparent film of greater clarity and higher tensile strength than is obtained from commercial methyl cellulose solutions. The viscosity decreases on warming and unlike the alkyl celluloses, it will not gel at higher temperatures. In contrast with polyvinyl alcohol, this hydroxyethyl cellulose film is completely soluble after drying in either cold or hot water. Also its light and heat stabilities are superior to those of polyvinyl alcohol. It is of interest for sizing applications in which starches, gums, gelatins, soluble resins and other thickening agents are commonly used in textile finishing, paper sizing and in shoe and leather dressings. Its application requires a single operation and it can be infinitely diluted with water without precipitation. The hydroxyethyl cellulose resulting from the drying of the water soluble solution can be made less water soluble by the addition of glyoxal before drying.

If 5 parts by weight of 30 percent glyoxal is dissolved in 50 parts of the WS solution and the water is evaporated with subsequent drying at 105 deg. C., a clear, glassy product of good tensile strength results. It is not affected by water except after soaking and it is extremely insoluble in oils, greases and or-



IT isn't enough to choose filter fabrics by construction alone. When you specify MT. VERNON Extra you discover a degree of uniformity, which assures maximum efficiency in filtering operations. MT. VERNON Extra filter fabrics are made under rigid laboratory control from the careful selection of top grades of cotton to their final weaving operation. Specify MT. VERNON Extra and watch filtering efficiency climb.

MT. VERNON WOODBERRY MILLS, INC.

TURNER HALSEY COMPANY
Selling Agents
40 WORTH STREET • NEW YORK, N. Y.
CHICAGO · NEW ORLEANS · ATLANTA · BALTIMORE · BOSTON · LOS ANGELES · SAN FRANCISCO

A Tough Fire Hazard...

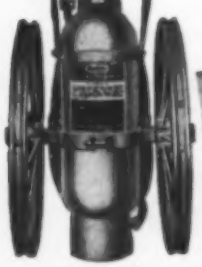
A Tougher FIRE FIGHTER!

This is just another spot where DUGAS Fire Extinguishers are on the job. Ready for action!

Applied from the DUGAS pressure-type extinguishers, PLUS-FIFTY DUGAS Dry Chemical makes short work of dangerous flammable liquid or gas fires. Knocks them out with tremendous speed!

Less hazardous for the operator, too, because PLUS-FIFTY DUGAS Dry Chemical does its work from safe distances. Non-toxic, non-corrosive, it hurts nothing except fire.

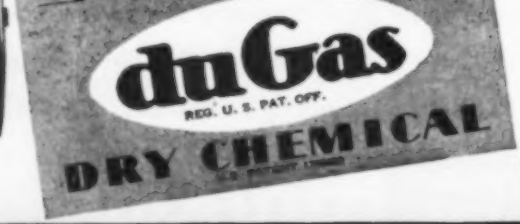
Write for complete information regarding DUGAS PLUS-FIFTY Dry Chemical—and for priority facts about DUGAS Fire Extinguishing Equipment.



MODEL 150 WHEELED EXTINGUISHER

Approved by Underwriters' Laboratories and Factory Mutual Laboratories.

CHART showing characteristics of all types of approved hand fire extinguishers sent free on request.



MODEL 30-T HAND EXTINGUISHER

DCM—2-44

DUGAS ENGINEERING CORPORATION, MARINETTE, WISCONSIN

OWNED AND OPERATED BY ANSUL CHEMICAL COMPANY

ganic solvents. Fiber containers lined with such a film have held lubricating oil, ethylene dichloride and other hydrophobic solvents for two years without leakage.

The co-acetal of the hydroxyethyl cellulose with glycerol and glyoxal greatly increases the wet strength of paper when used in small amounts. Thus a single impregnation of high grade viscose-strengthened paper toweling, followed by a two-minute drying at 90 to 100 deg. C. yielded a product that had increased in weight 1.34 percent over the dry weight of the toweling, while the wet strength had increased 20 percent over the wet strength of the untreated material. Two successive impregnations increased the weight 2.7 percent, resulting in an increase of dry strength of 24 percent and wet strength of 126 percent of the strength of the untreated toweling.

Tentative Specifications

Specific gravity at 20/20° C.	1.035 to 1.040
Concentration, %	10 to 12
pH	6.0 to 7.0
Water miscibility	Complete
Ash content after drying and ignition, %	0.05 to 0.30
Viscosity (Hoeppler) at 20° C. after dilution with equal weight of water, centipoises	100 to 150
Flash point. Dried film burns less readily than paper	None
Average weight per gal. at 20° C., lb	8.6

COATINGS

ELECTRICALLY conductive coatings of a ceramic type composition containing silver powder have been developed by the Electrochemicals Department of E. I. du Pont de Nemours & Co., Wilmington, Del. The coatings may be applied to a wide variety of non-conductors including glass, plastics, porcelain, soapstone, wood, cloth and paper. They can be applied to non-conducting base materials by spraying, dipping or brushing followed by air drying and in some cases baking. A thermoplastic conductive cement is one form. Others contain a conductive coated cloth and a flexible conductive film.

SYNTHETIC RUBBER-RESIN

PLASTICIZED vinyl chloride resins have been united with certain butadiene type synthetic rubbers to effect vulcanizable blends possessing most of the best properties of each material, thus closing the gap between plastics and rubbers, R. A. Emmett, of the B. F. Goodrich Co., Akron, Ohio, stated in a paper presented before the Rubber Division of the A. C. S. Vulcanizable blends ranging from 75 parts of oil-resistant synthetic rubber such as Hycar OR and 25 parts of the GEON resins to 50 parts of the rubber and 50 of resin are obtainable which are easily processable by usual rubber industry techniques and yield products serviceable over an exceptionally wide range. Compositions made from these blends can be extruded, molded, calendered, or spread. A mirror-like finish can be produced. Properties possessed by the combination of the two materials which are better than when the oil-resistant rubber is used alone are extreme resistance to the effects of sunlight and ozone, increased resistance to benzene and similar aromatic solvents, both in swelling and cracking, low temperature flexibility combined with excellent heat resistance.

GLASS-ASBESTOS TEXTILE

BY COMBINING glass and asbestos fibers a new textile has been made which is being employed as a protective boot in war planes. In fabric form it is used for gun boots, tail-wheel boots and in P-47 Thunderbolts to protect retractable landing gear from the hot exhaust of the supercharge. In cord form the textile is used for shroud lines on military glares.

The glass-asbestos textile is intended for applications requiring high strength combined with light weight, high abrasion resistance and resistance to high temperatures and corrosive fumes. In textile terms, the combination glass-asbestos cloth may be classified as an inorganic canvas or duck. Applications to date point to many possibilities for the use of the new textile, but because of limited production it can be supplied only under a high priority or end use rating. The textile is being supplied by Owens-Corning Fiberglas Corp.

HIGH-BOILING HYDROCARBON

A CLEAR, mobile high boiling hydrocarbon which is said to have a unique combination of chemical and physical properties, is HB-40, developed by Monsanto Chemical Co., St. Louis, Mo. Among the suggested uses are: (1) as a hydraulic fluid in thermal controls, (2) as a plasticizer for vinyl, polystyrene, methacrylate resins and for asphalt or gilsonite base paints, (3) as a textile lubricant and softener, in particular for rayon and woolen goods, (4) as a solvent for various types of oils, resins and waxes, (5) as an absorber to remove volatile organic compounds from gases.

Physical Properties

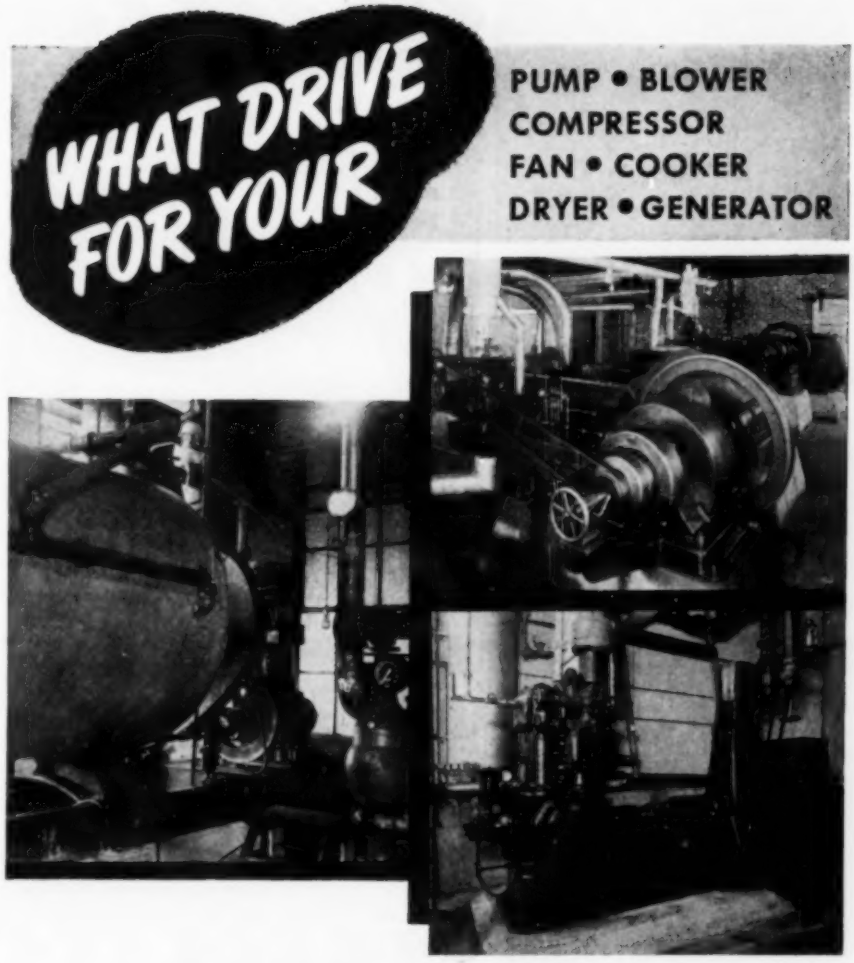
Appearance: Almost colorless, mobile, oily liquid, with faint pleasant odor.
Color: Less than 500 APHA (Darkens on exposure to sunlight.)
Specific gravity: 1.005 ± 0.010 at 25/15.6 deg. C.—(8.37 lb./gal., average).
Refractive index: 1.5540 — 1.5740 at 25 deg. C.
Coefficient of expansion: 0.000741 cc/cc/deg. C.
Carbon residue: (Conradson) 0.02%.
Ash: (10-gram sample) nil.
Neutralization number: 0.03.
Steam emulsion value: 45.
Stability to heat: Appears to be relatively stable at the boiling point (at least in glass), and does not readily oxidize. However, it does decompose at 300 deg. C. under pressure, in iron.
Stability to acids and alkalis: Appears to be relatively stable, and undergoes no significant changes in composition when kept in contact with boiling 10% aqueous solutions of H_2SO_4 or NaOH at atmospheric pressure.

Distillation Range:	Deg. C.
Start	345 (corr.)*
10%	353 "
50%	359 "
90%	393 "
95%	420 "

*Corrected for steam exposure.
Flash point: 345 deg. F. ASTM D92-24.
Flame point: 385 deg. F. ASTM D92-24.
Pour point: Minus 28 deg. C.
Solubility: Not soluble in water, but is miscible in all proportions at room temperature with a number of solvents and oils.
Compatibility: Compatible in varying proportions with polystyrene, ethyl cellulose and methacrylate resins.
Viscosity—SUS. 136.5 at 100 deg. F.
38.4 at 210 deg. F.
Electrical properties: (Typical Data).
Dielectric constant: 2.53 at 25 deg. C., 2.35 at 100 deg. C.
Dielectric strength: 30 kv., average, at 25 deg. C.
Resistivity: $5000 \times 10_9$ ohms/cm$_3$ at 100 deg. C.
Above $17,000 \times 10_9$ ohms/cm$_3$ at 25 deg. C.
Power factor: 0.12% at 100 deg. C. at 1,000 cycles.

RUBBER ACCELERATORS

Two new vulcanizing accelerators for synthetic rubber, both chemical compounds of copper, were announced at the



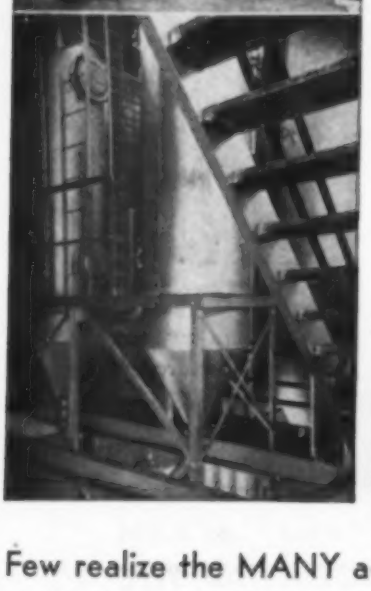
IF YOU CAN USE EXHAUST STEAM FOR HEATING OR PROCESSING, THE CHOICE SHOULD BE A . . . . .

TROY-ENGBERG STEAM ENGINE

The modern steam engine is a producer of By-Product Power which, in many plants, is the cheapest power obtainable. Hundreds of Troy-Engberg Steam Engines are driving equipment such as listed above at a cost so low as to have completely paid for themselves in two or three years, even less. They exhaust into heating coils with most of the heat units originally in the live steam. Thus steam is made to work twice — to yield power at low cost and to provide heat units.

Keep these *engine facts* in mind when considering a drive for your equipment.

TROY ENGINE & MACHINE CO.
ESTABLISHED 1870
1320 RAILROAD AVENUE TROY, PENNSYLVANIA



DRACCO PNEUMATIC CONVEYORS Offer 10 Practical Advantages

Few realize the MANY advantages that DRACCO Pneumatic Conveyors offer. There are 10 factors that contribute to the efficient handling of chemicals. All installations enjoy most of these advantages and some all of them, depending upon the chemicals handled and the nature of the installation. Here are the advantages offered by DRACCO Pneumatic Conveyors: (1) control of dust when transporting powdered material, (2) continuous automatic operation, (3) low maintenance cost, (4) labor saving, (5) improved working conditions, (6) lower cost of material due to receiving same in bulk, (7) saving in cost of packaging, (8) no loss of material in handling, (9) no contamination, (10) no interfering with the existing machinery.

• *For Further Information write* •

DRACCO CORPORATION

4071 E. 116th St., Cleveland 5, Ohio • New York Office, 130 W. 42nd St.

PNEUMATIC CONVEYORS • DUST COLLECTORS

recent Rubber Division meeting of the A. C. S. by Dr. A. A. Summerville of R. T. Vanderbilt Co., New York, N. Y. Known as Cumate and Cutrax, the accelerators are said to be several times as powerful as the conventional type now in use in the rubber industry. The new copper accelerators, it is understood, can be used in conjunction with other standard rubber accelerators. So that the supply and requirements situation in the rubber industry will not be upset, these new accelerators do not require special equipment for their manufacture. In Buna S, copper acts as a catalyst of vulcanization, not as a catalyst of oxidation.

RUBBER FROM LACTIC ACID

A SYNTHETIC rubber made from lactic acid was described by C. H. Fisher, W. C. Mast, C. E. Rehberg and Lee T. Smith of the Eastern Regional Research Laboratories, Philadelphia, Pa., at the recent meeting of the Rubber Division, A. C. S. The new rubber is known as Lactoprene. The acid is transformed into methyl acrylate and then into the rubber compound.

STYRENE DIBROMIDE

STYRENE DIBROMIDE has revealed interesting applications in current laboratory work. One important development has led to its use as an ingredient in a specially formulated corn ear worm control. It is a product of the Dow Chemical Co., Midland, Mich. This new chemical is slightly colored, is in the form of coarse granules, with a persistent characteristic odor. The melting point is between 71 and 73 deg. C.

Solubility—grams per 100 grams at 25 deg. C.

Acetone	154
Benzene	158
Carbon tetrachloride	50
Methanol	12
VMP naphtha	18
Water	Insoluble

VULCANIZING AGENT

EXTENSIVE tests have shown that alkyl phenol sulphides serve the dual purpose of imparting tack and acting as vulcanizing agents for GR-S ruber. p-tertiary-amylphenol-disulphide is an example of this class of vulcanizing agents which mixes readily with synthetic rubber of the butadiene type to impart upon vulcanization superior tensile strength and improved elongation, together with greater resistance to tear and cracking under flexure. All of these factors contribute to the improvement of the rubber.

The improved synthetic rubber compositions made available through the use of these new organic vulcanizing agents, are outstandingly resistant to deterioration by heat, and as such give promise for such applications as inner tubes and the carcass section of tires. These agents by virtue of both their tack-imparting quality and vulcanizing power are proving of interest in the formulation of rubber footwear stocks. They are also adapted to the manufacture of improved synthetic rubber goods for industrial uses, G. M. Wolf, T. E. Deger, H. I. Cramer and C. C. deHilster of Sharples Chemical, Inc., Wyandotte, Mich., told the Rubber Division of the A. C. S. at its April meeting.

SEALING TAPES

NATIONAL distribution of Filmonize, a complete line of pressure-sealing tapes, has just been announced by the International Plastic Corp. of Morristown, N. J. Now available through wholesalers, paper and mill supply jobbers on an "end-use" statement, each of these self-sealing tapes has actually been developed with certain special properties for specific industrial applications and military uses.

The full Filmonize line consists of: transparent tapes; single and multi-colored tapes; printed, (numerical, alphabetical, or specially designed combinations); riveting, luminous, electrical, and masking tapes. Widths range from ½ in. to 18 in. All tapes have high tensile strength. They are weatherproof, highly resistant to moisture and vapor penetration and unaffected by extreme temperatures, sea air, salt spray, chemical fumes, or war gases. Every tape is an adaptable, dependable, tough tape made to handle the many new applications for tape in the factory and on the fighting front.

Filmonize won't curl back into a messy tangle. Sturdy acetate backing reduces curl-back and telescoping and ends all stretching and shrinking. They skim off the role easily and ready for immediate use. The firm adhesive, exclusive with Filmonize does not "ooze" under pressure.

RUBBER PLASTICIZER

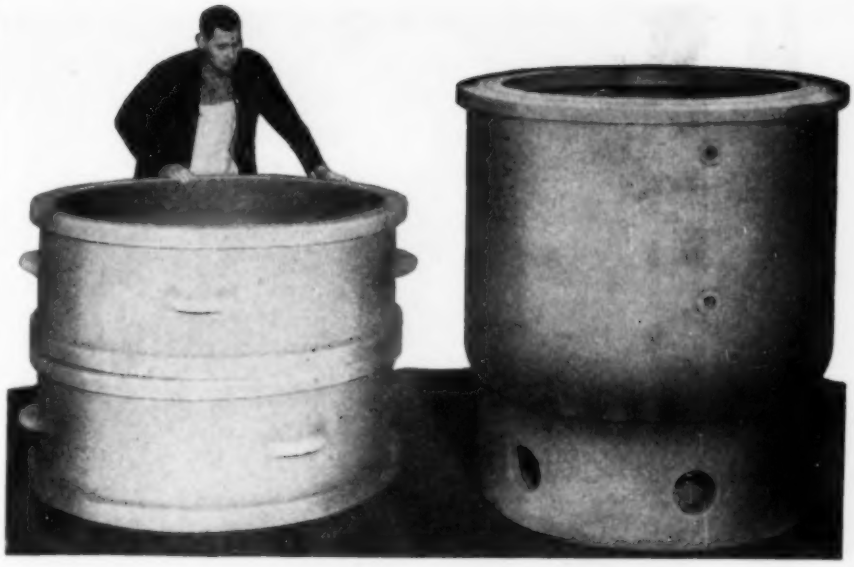
A CHEMICAL plasticizer developed in the Du Pont laboratories is helping to solve the problem of making GR-S synthetic rubber behave more like natural rubber in the fabrication of tires, it was reported at the annual meeting of the Rubber Chemicals Division of the American Chemical Society.

One of the big differences between natural rubber and GR-S is that the synthetic product is much more difficult to soften or plasticize by rubber mills and mixers prior to incorporation of the compounding ingredients.

Data were presented that showed these milling properties were improved by the plasticizers known as R.P.A. No. 5. The chemical was developed by Drs. B. M. Sturgis and J. R. Vincent, of the Du Pont company's Jackson Laboratory, at Deepwater Point, N. J.

Natural rubber begins to soften as soon as it starts through the milling and mastication process just as a stick of gum begins to soften as soon as you chew it. In the absence of the chemical plasticizer, the GR-S, however, will decrease tremendously in workability during the first ten minutes of milling at high temperature. But upon further milling, this stiffening effect disappeared. It was as though your gum became stiffer as you chewed, and then began to soften.

When the R.P.A. No. 5 was added, to the extent of two percent, this period of stubborn stiffness disappeared and the synthetic began to soften up properly as soon as the milling was started. Furthermore, instead of higher temperatures decreasing the workability, as they had in the absence of the plasticizer, they actually speeded up the processing when the plasticizer was added. The laboratory tests suggested that use of the plasticizer might lead to in-



Acid-Proof Filters for Making Fine Chemicals and Drugs

ABOVE is a photograph of a 400-gallon filter made of acid-proof Knight-Ware for use in the manufacture of fine chemicals and drugs. Actually, the bottom section holds 300 gallons and the upper part (one of the sections at left), 100 gallons.

Standard filters are available in 5 to 200 gallon sizes. Knight also makes special designs and sizes to meet customers' specifications. All these filters are built to stand a full vacuum.

Knight-Ware filters, jars, tanks, kettles, coils, pipe, fittings and valves are thoroughly vitrified, uniform and tough. The entire body, not just the glaze, is inert to action of acids, alkalies and chemicals.

Because Knight engineers have had many years' experience with problems involving the handling of acids, alkalies, gases and chemicals, the industry looks to them for the most practical type of acid-proof equipment when special needs arise.

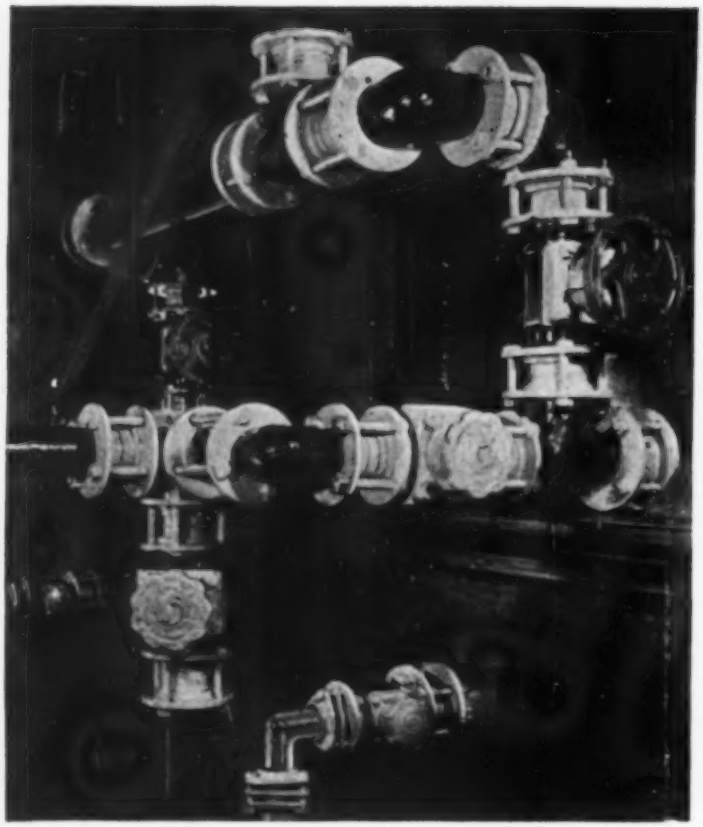
While Knight makes and stocks many standard pieces, most of its business is tailor-made equipment of special design to fill customers' needs. When making inquiry, give us as much data as you can regarding your requirements and we will be glad to give you our recommendation and quote prices.

MAURICE A. KNIGHT

105 Kelly Ave., Akron 9, Ohio

KNIGHT-WARE CHEMICAL EQUIPMENT

H A V E G



Plastic Piping • Valves Fittings • Fume Duct for acids and alkalies

Completely chemically resistant throughout its entire mass, HAVEG provides efficient means of handling corrosive liquids and fumes. HAVEG piping and fittings are stocked in standard sizes from ½″ to 12″ I. D. inclusive. HAVEG fume duct is made in standard sizes 2″ to 36″ I. D. inclusive. Standard and Special Fittings and Valves are available to meet specific problems. Bulletin F-3 gives complete design, application and chemical resistance data. Send for a copy today.

HAVEG-SARAN Tubing; Pipe & Fittings; and sheets are available from stock. HAVEG-SARAN is also described in Bulletin F-3. Send for a copy now.

HFP-43

HAVEG CORPORATION
NEWARK, DELAWARE
FACTORY–MARSHALLTON, DELAWARE

CLEVELAND 550 Leader Building | CHICAGO 1201 Palmolive Building | DETROIT 2832 E. Grand Blvd. | LOS ANGELES 601 W. Fifth St.

creased production from existing equipment at a time when additions are difficult to make.

FIRE-RESISTANT MATERIAL

Millions of man hours have been saved, and practically all metal has been eliminated from heating and ventilating air-duct systems of aircraft by the discovery and development by the United States Rubber Co., New York, N. Y., of a fire-resistant asbestos product. Made of fabric, asbestos and a synthetic coating of resin, this new product makes possible the lightening of the material used on these heating and ventilating air-duct systems by more than 10 percent.

The development of this pliable fabric has made possible high-speed production schedules in the aircraft industry for it can be twisted and turned or completely deformed and can be easily returned to its original shape without effort. Unlike metal which has rigidity, it can be used in many places where pipe bending would be a must.

THIOCYANATE INSECTICIDE

A powerful synthetic insect-killer promises this season to meet vegetable growers' urgent need for an insecticide to replace the war-scarce natural insecticide used to control aphids, leafhoppers and other insect pests. Known as Lethane B-71, this new synthetic was developed before Pearl Harbor and has undergone three years of extensive field testing on tomato, pea, bean, spinach and cabbage crops by large growers and State Experiment Stations. For the control of certain sucking insects on these essential crops, the chemical has demonstrated a killing power equal to nicotine, rotenone and pyrethrum.

This synthetic developed by the Rohm and Haas Co. of Philadelphia has demonstrated a high kill on such sucking insects as leafhoppers and aphids, and has proved harmless to vegetable crop foliage. For these sucking insects, a finished insecticide based on this thiocyanate is a complete replacement for dusts containing retenone, pyrethrum, or nicotine.

Lethane B-71 is available to dust mixers as a dry concentrate, which requires simple extension with proper carriers to manufacture the finished dust.

HIGH ARC-RESISTANT RESIN

Resimene 803A has been developed to answer the demand for an easily molded plastic with high arc-resistance. It is a cellulose filled melamine-formaldehyde molding compound with the moldability of a general purpose phenolic plastic. Specifically, Resimene 803A has an arc resistance of 120 seconds (ASTM-D495-41), excellent electrical insulating properties, and mechanical properties superior to general purpose phenolic plastics.

Other characteristics of the entire family of Resimene molding compounds and industrial resins are (1) high heat resistance, (2) wide color range, (3) low water absorption, (4) acid and alkali resistance, (5) resistance to boiling water, (6) odorless, tasteless, inert to organic solvents, (7) hard, permanent surface, (8) high tensile and compressive strength, and (9) good flexural strength.

CHEMICAL ENGINEERING NEWS

ALCOHOL PROGRAM MEETS WITH REVISION

PLANS FOR new production of alcohol and for distribution of current outputs continue to meet with revisions as consuming requirements become more clearly defined. From the standpoint of new production, the most important development in the last month was the refusal of the Requirements Committee of WPB to approve allocation of materials for the proposed plants at Springfield, Ore., and Clewiston, Fla. The Clewiston plant was designed to have a potential capacity of 7,000,000 gal. of alcohol a year and was to use sweet potatoes of a high starch content as a raw material.

The plant proposed for Oregon was for the Willamette Valley Wood Chemical Co. and was to have an annual capacity of 4,100,000 gal. of alcohol with wood waste as the main raw material. Disappointment over the decision of the committee was especially keen as these two projects had been approved by the Chemicals Bureau of WPB. For Oregon, however, approval has been gained for the manufacture of alcohol from cull potatoes. This will be carried out in a plant at Carver near Portland. This is the plant of the Oregon Brandy Distillery which has long been idle and which was purchased last year by Grain Products, Inc.

Production of alcohol in March established a record with 51,500,000 gal. of 190 proof produced as against the previous high of 46,700,000 gal. turned out last January. Of the March output, 4,000,000 gal. came from new capacity. Stocks at the end of March were 85,200,000 gal. It is pointed out that the synthetic rubber industry is calling for alcohol in a large way and was currently consuming about 1,000,000 gal. a day.

Walter G. Whitman, assistant director of the Chemicals Bureau, has been able to cut down estimated requirements for some of the groups so that the grand total has been brought down to 630.5 million gal. as against an earlier estimate of 638 million gal. In the revised estimate requirements for synthetic rubber were advanced to 365 million gal. Anti-freeze allotments were unchanged at 32 million gal. but other groups were placed on a lower requirement basis.

CALIFORNIA RUBBER PROJECT IN FULL OPERATION

A TWO-YEAR battle for rubber was climaxed by the announcement April 24 that Rubber Reserve's California synthetic rubber project, rated to produce one-eighth of all GR—S type rubber in the nation, is completed and in full operation. Six companies which operate the Los Angeles units for Rubber Reserve Co. have shared their talents and resources to accomplish the gigantic task of converting chemical synthetic rubber formulas into a mass production industry.

Six operational plant units, which were begun in Sept., 1942, cover about 250 acres. Southern California Gas Co., Standard Oil Co. of California, and Shell Chemical Division of Shell Union Oil Corp. produce and refine the butadiene, Dow Chemical Co. makes the styrene, and Goodyear Synthetic Rubber Corp. and U. S. Rubber Co. combine the two materials in three copolymer plants.

While six companies operate the central units, many other West Coast sources contribute to production. Raw materials for making butadiene can be secured from almost all of California's oil producers. Dow Chemical's styrene unit receives alcohol from the wine distillers of the Pacific Coast, benzol from Kaiser's Fontana coke ovens and the Portland (Ore.) Gas and Coke Co. From Utah and California's desert areas comes rock salt, 70 tons of which are used daily as a coagulating agent.

At its rated capacity of 90,000 tons annually, the California project can produce enough rubber to make 54,000 passenger tires daily, or one set of tires yearly for every car on the Pacific Coast.

The project is a highly integrated chemical process in which plants are linked together in a continuous production flow from petroleum, benzene and alcohol though butadiene and styrene to pelmerization units.

Raw butadiene stocks produced by Southern California Gas Co. flow to the Shell Chemical plant where the butadiene is extracted and purified. It is then compressed into liquid form and piped to the two rubber companies. Shell also operates a unit, which converts the residue from the extraction to butadiene. An additional supply of butadiene comes from a new Houdry type plant operated by Standard of California at El Segundo; the butadiene produced there goes directly to the rubber plants in pressure-type tank trucks.

JOHN WESLEY HYATT MEDAL GOES TO S. D. DOUGLAS

FOR accumulated results of 17 years study and development of plastics Dr. Stuart D. Douglas, head of plastics research, Carbide and Carbon Chemicals Corp., South Charleston, W. Va., on May 11 was presented with the John Wesley Hyatt gold medal. This medal which represents the most distinguished award for achievement in the plastics industry, is sponsored annually by Hercules Powder Co. and carries with it a cash gift of $1,000. The presentation was made at a special luncheon in the Edgewater Beach Hotel, Chicago, during the annual conference of the Society of The Plastics Industry. The presentation was made by Dr. Carl Shipp Marvel, professor of organic chemistry at the University of Illinois and president-elect of Am. Chemical Society.

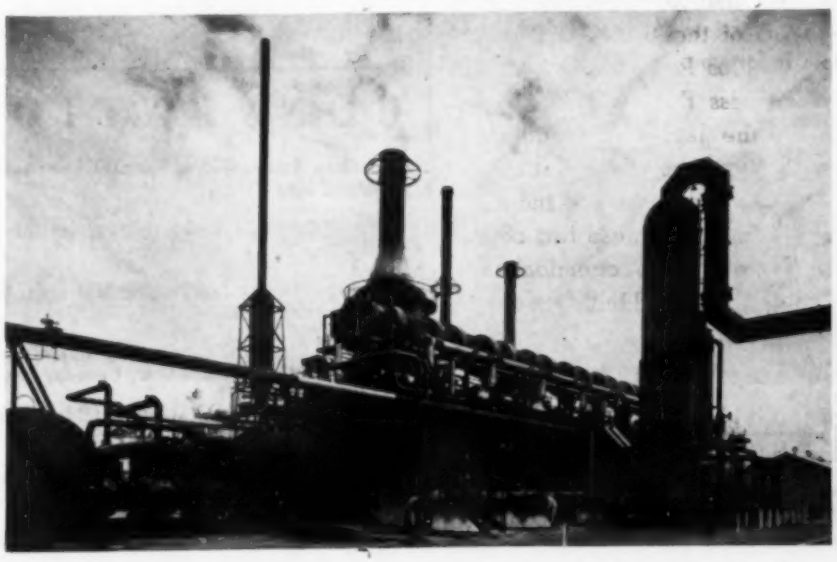
"GOON" GUNS AND "GOOP" BOMBS EFFECTIVE IN COMBAT

Two Chemical Warfare Service items are attracting particular attention by reason of their odd names as well as because of their effectiveness in combat. They are the "goon" gun and the "goop" bomb.

The former is the nickname of the 4.2 chemical mortar which, in operation in the Mediterranean and Pacific areas, has shown remarkable versatility in firing phosphorus, smokescreens and high explosive.

Not related to the "goon" gun is the so-called "goop" bomb. The latter is one type of aerial incendiary made by the Chemical Warfare Service for the Army Air Forces. It is a 500-lb. blockburner. The term "goop" was applied to it in its development process. "Goop" is a slang expression used in laboratory and kindred research work to denote a miscellaneous sticky mass. The fiery, jellied oil contents of the "goop" bomb is just that.

Butadiene Plant of Standard Oil Co. of California



GRINDS PAINT

in half the time

WITH PAUL O. ABBÉ MILL

☆

RESULTS OF A TEST—

made without our knowledge, by an important paint manufacturing concern, and repeatedly checked by them in subsequent batches of paint.

Two mills of equal rated capacity, one of them a Paul O. Abbé mill, were concerned in the test.

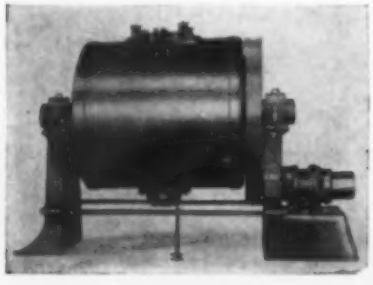
The Paul O. Abbé Ball Mill did the work in *half the grinding time* required by the other mill.

HERE ARE THE SPECIFICATIONS:

	P.O.A. 5' x 6' Ball	Other Mill 5' x 6' Ball
Type of Mill		
Rated Capacity	530 Gals.	530 Gals.
Grinding Medium	Steel Balls	Steel Balls
Product	High Grade Enamel	High Grade Enamel
Time Consumed to secure identical degree of dispersion	8 HOURS	16 HOURS
Speed	Same as of other mill	Same as of P.O.A. mill

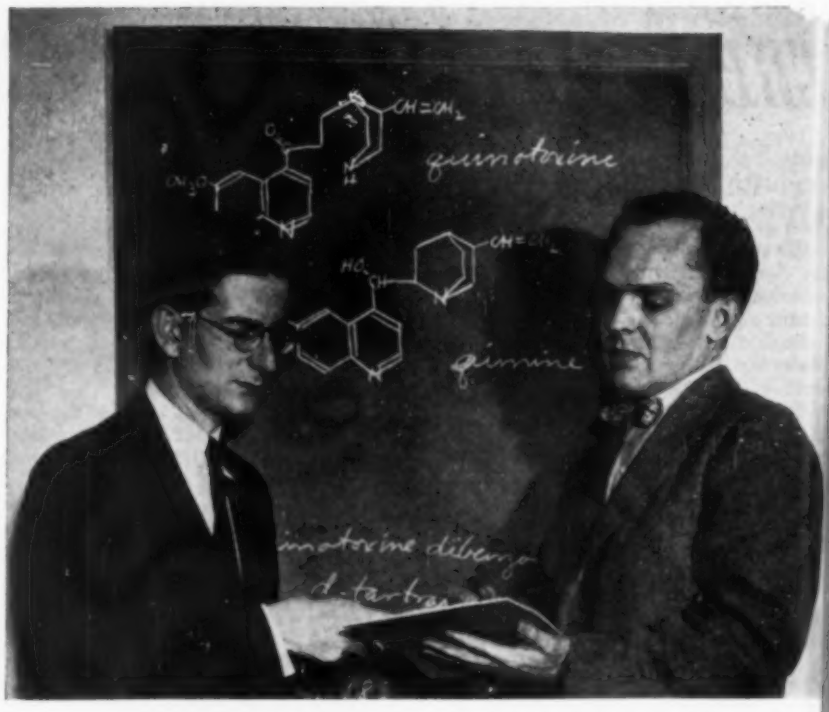
SIMILAR TESTS made elsewhere confirm this time saving and other efficiency factors in Paul O. Abbé mill operation.

If you want the highest efficiency in your own grinding department, write Paul O. Abbé about the equipment to attain it for you.



PAUL O. ABBE

OF LITTLE FALLS, NEW JERSEY
375 CENTER AVENUE



Dr. Robert B. Woodward and Dr. William E. Doering

SYNTHESIS OF QUININE HAS BEEN ACCOMPLISHED

ANNOUNCEMENT was made early in this month at Cambridge, Mass., by the Polaroid Corp. that a chemical method for duplicating quinine, identical with the drug extracted from the bark of cinchona trees, has been developed after almost a century of effort to find the correct process. The plan for synthesizing the complex drug was originated by Dr. Robert B. Woodward and incorporated as a project in the basic research program of the Polaroid Corp. early last year. Dr. Woodward, who is instructor in organic chemistry at Harvard University, has been chemical consultant to Polaroid since June 1942. Dr. William E. Doering, who is now instructor in organic chemistry at Columbia University, was engaged by Polaroid to work as a collaborator on the project.

The two scientists took less than 14 months to complete the work of producing a new synthetic material which is described as a precise duplicate of natural quinine. They have an article in the current issue of the *Journal of the American Chemical Society* describing how they solved the problem. Edwin H. Land, president and director of research of the Polaroid Corp., said it has not been determined whether the intricate process involved in this synthesis can be made commercially practicable. He further states that his company does not plan to make the product but will license the process.

SPECIFICATIONS FOR BASIC CARBONATE OF LEAD

STANDARD specifications for basic carbonate white lead has recently been approved by the American Standards Association. These specifications, developed by the American Society for Testing Materials' Committee D-1 on paint, varnish, lacquer and related products, were first adopted by the ASTM in 1924.

CONVENTION CALENDAR

American Association of Cereal Chemists, annual meeting, Nicollet Hotel, Minneapolis, Minn., May 23–25.

Institute of Food Technologists, annual meeting, Edgewater Beach Hotel, Chicago, Ill., May 29–31.

American Society for Testing Materials, annual meeting, Waldorf-Astoria, New York, N. Y., June 26–30.

Canadian Chemical Conference, annual meeting of Canadian chemical societies, Royal York Hotel, Toronto, Ont., Canada, June 5–7.

National Association of Insecticide & Disinfectant Manufacturers, annual meeting, Chicago, June 12–13.

American Association of Textile Chemists and Colorists, annual meeting, Claridge Hotel, Atlantic City, N. J., Oct. 12–14.

Third National Chemical Exposition, Chicago Coliseum, Chicago, Ill., Nov. 15–19.

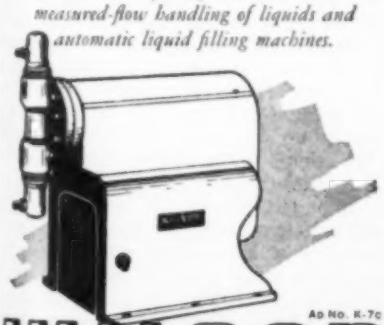
Loyal Allies of the Absent

We feel that we are loyal allies of our own absent and that we must support our fighting men even more loyally than we expect their foreign allies to support them.

We conscientiously continue to turn out WILSON *Pulsafeeders* by the thousands because they are purifying water and helping to maintain sanitation for our fighting forces all over the world.

They also serve in compounding medicines and filling precious ampoules in laboratories; increase production of processed foods; help do amazing things with chemicals. They are as nearly infallible and accurate as precision machines can be.

WRITE... for information about measured-flow handling of liquids and automatic liquid filling machines.



AD NO. K-7C

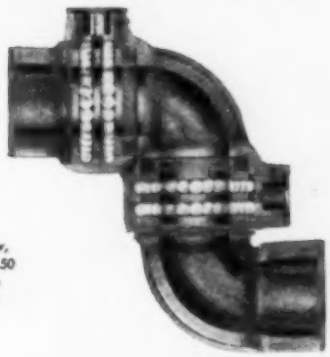
WILSON

CHEMICAL FEEDERS, INC.

214 Clinton St. (P. O. Box 998) Buffalo 4, N. Y.

for 1920 ... with Experience in Allied Lines Since 1914

FROM SUBSTRATA TO STRATOSPHERE



Phantom View, Chiksan Style 50 Ball-Bearing Swivel Joint

CHIKSAN **Ball-Bearing** Swivel Joints are delivering safe, dependable, economical service through extreme ranges of temperature and pressure. They provide for easy swiveling or complete rotation with minimum torque and positive sealing under pressure or vacuum.

Double rows of ball bearings assure easy turning; the self-adjusting Packing Element requires no maintenance attention. There is nothing to tighten or adjust.

With more than 500 different Types, Styles and Sizes for transferring water, oil, gas, steam, chemicals, etc., there is a Chiksan **Ball-Bearing** Swivel Joint to fit every need. Write to Dept. S for Latest Catalog and Engineering Data.

CHIKSAN REPRESENTATIVES IN PRINCIPAL CITIES

CHIKSAN

CHIKSAN TOOL COMPANY

Ball Bearing SWIVEL JOINTS for ALL PURPOSES

BREA, CALIFORNIA

. . . Standard Spiral Chutes move merchandise from upper to lower floors . . . with SPEED and minimum handling cost

If you have material on the second floor—or the twentieth, for that matter—and want to get it to street level or the basement, there are several methods you could use. You could carry it down, step by step, or use an elevator.

A better method — quickest and lowest in cost — is the spiral chute. The spiral chute has volume carrying capacity, runs up no power bills, and is always ready for service. It reduces handling costs and saves time.

Scientifically pitched and skillfully designed spiral chutes are part of Standard's wide line of handling equipment, developed during almost forty years of solving industry's inside-the-plant transportation problems.

Get complete information on Standard Spiral Chutes and how they can be used to advantage for the handling of a wide range of products and merchandise.

STANDARD CONVEYOR COMPANY
General Offices: North St. Paul, Minn.
Sales and Service in Principal Cities

Write for valuable reference book—"Conveyors by Standard" —Catalog No. CM-54

★ ENGINEERED FOR FASTER PRODUCTION ★

HIGH-OCTANE GASOLINE PLANT IN WYOMING

ANOTHER completed 100-octane gasoline refinery, costing $8,000,000 and covering 40 acres of prairie land at Cheyenne, Wyo., was dedicated last month as the massive plant went into full operation.

Owned by the Frontier Refining Co. of Cheyenne under authority from the defense plant corp., the plant is one of the largest and most modern in the country. It contains over 115 towers, vessels and structures, comprising a 12,000,000 gallon storage area, a 360-foot cooling tower and 132-foot catalytic cracking unit, among others. Engineer-contractor for the plant was Fluor Corp., Ltd., of Los Angeles, Calif.

Plant design provided for utilization of many processes licensed to Universal Oil Products Co. of Chicago, including fluid-flow catalytic cracking, hydrogen fluoride alkylation, butane isomerization and thermal reforming. Universal technicians worked with M. H. Robineau, president of Frontier, in making plans for the plant which subsequently were approved by the petroleum administrator for war.

Already looking to the peacetime future of the gigantic refinery, Mr. Robineau predicted the chemical possibilities of the installation will react to the advantage of the entire Rocky Mountain West. He disclosed Frontier is at present engaging in an exploration program seeking independent supplies of crude oil to bolster operations in the postwar period. Over 100,000 acres have been leased by the company and field surveys are complete on seven structures which will probably be tested within the next year.

CLEARING CYLINDERS THROUGH CUSTOMS

THE Compressed Gas Manufacturers Association has called attention to a simplified procedure for clearing cylinders through customs, developed by Stanley Williamson of Union Carbide Corp. Difficulties found in this respect of late have made the subject of current importance and it is felt that the Treasury Department or the Customs Bureau in Washington will not issue an order to all port collectors to follow the simplified procedure some of the collectors adopted as much as three years ago. Hence it is suggested that better progress can be made by taking the matter up with the individual collectors. The simplified procedure recommended is as follows:

Importers file at the various ports of entry a term bond written by a surety company which includes and provides for a single entry privilege so that when cylinders are entered it is not necessary to file a bond. Contemporaneous with entry, the importer's custom broker should make an affidavit on customs form No. 3311, termed American Importers Oath. Importers should also file with the appraiser a list of the various types of cylinders they import, showing thereon the particular ICC markings and the name of the American maker of the cylinders. With this list the importer should send an affidavit by one of his executives to the effect

that all of the cylinders owned and operated by them are of American origin and made by American manufacturers.

REPORT ON TRADE PACT WITH ICELAND

THE United States Tariff Commission has just issued a report entitled Trade Agreement between the United States and Iceland. The introduction to the report contains a discussion of the economy of Iceland; a brief analysis of the trade between the United States and Iceland; and a summary of the reciprocal trade agreement, which became effective November 19, 1943. The main body of the report consists of digests of trade data relating to the classes of imported merchandise upon which the United States, under the terms of the agreement, granted tariff concessions in the form of rate reductions for some commodities and commitments to continue others on the free list. The information contained in these digests was made available by the Tariff Commission to the interdepartmental organization responsible for the negotiation of the agreement.

A copy of the report may be obtained upon application to the United States Tariff Commission, Washington 25, D. C.

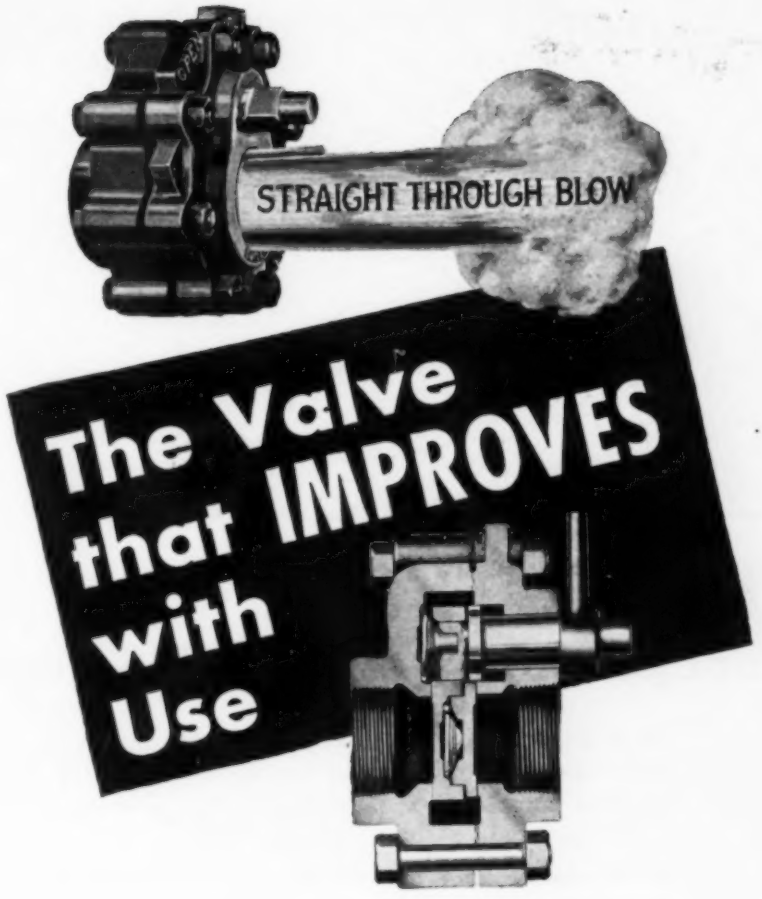
TEXTILE CHEMISTS WILL MEET IN ATLANTIC CITY

THE American Association of Textile Chemists and Colorists is making its plans for the annual convention which is to be held at the Claridge Hotel in Atlantic City, on Oct. 12–14. The arrangements are under the supervision of the Philadelphia Section of the Association, the chairman of which is Boyce G. Bond of the General Dyestuff Corp.

Because of war time restrictions in travelling, this annual meeting will be devoted entirely to an appropriate technical program, including the annual intersectional contest. This will be the fifth contest which the Association will hold and the various sections are now setting up local committees which will be charged with the preparation of a suitable technical paper for presentation on this occasion. Previous contests have produced contributions of considerable value to the textile industry.

SALES OF CHEMICAL LIME INCREASED LAST YEAR

IN A REPORT on the lime industry the Bureau of Mines says that the tonnage of chemical lime sold in 1943 advanced to 4,075,000 short tons a gain of 8 percent over the former record annual quantity sold in 1942. The increased demand reflects principally the greater activity in production of steel, glass, calcium carbide, and Bayer alumina, of which all showed appreciable gains in the year. Demand for lime for water purification probably rose slightly as a continuation of the upward trend in sales for this use in recent years. In other industries that are major consumers of lime—insecticides, paper mills, and tanneries—demand probably was lower than in 1942.



In the unique EVERLASTING Valve, the Disc never leaves the seat, even when the valve is full open. The Disc moves across the sealing surface with a rotating motion, thus regrinding one to the other.

Therefore, this self-grinding movement of the Disc across the sealing faces, each time the valve is operated, continuously polishes the sealing faces, with the result that the seal actually improves with use.

This feature, coupled with the fact that the EVERLASTING Valve is quick acting, easy to operate and drop-tight, makes it the ideal valve for PROCESS lines where saving of time is essential and where leaks are objectionable.

Let an EVERLASTING solve your valve problems.

Write for Bulletin

EVERLASTING VALVE CO. **49 Fisk St., Jersey City 5, N. J.**

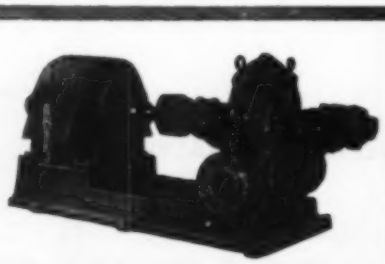
REJECTED . . .
but passed by the MORRIS Pump

Every stone in this mound . . . many of them large and heavy . . . has passed through the MORRIS material handling pumps located at the other end of the discharge pipes.

These stones were not wanted, and constitute a spoil bank, but they show the capacity and sturdiness of these MORRIS Pumps. Whatever may be the character of the materials you wish to convey hydraulically . . . whether sludge, slurry, sand, gravel, coal, paper pulp, sewage, trash, or other kind of material, you are sure to find the right unit in the large MORRIS line of material-handling pumps.

For 80 years, MORRIS has specialized on the "hard-to-handle" services, and this unequalled experience is at your service.

ST-P Non-clogging Pump — Guaranteed Non-binding for Pulpy Mixtures



Double Suction Horizontally Split Pump for Clear Liquids

MORRIS MACHINE WORKS
Baldwinsville, N. Y.

MORRIS
ESTABLISHED 1864

Export Office:
50 Church St.,
New York 7, N. Y.

CENTRIFUGAL PUMPS

CARBON BLACK OUTPUTS WILL BE INCREASED

With the expansion in production of synthetic rubber, requirements for carbon black have grown to a point where concern has been felt regarding the availability of supplies with the probability held out that it might be necessary to place this material under allocation. However, the situation has improved through steps taken to enlarge productive capacities of existing plants. It is further stated that new capaciy will be provided next year.

In order to help channel process plants in Texas now operating below capacity, a 60-mile natural gas pipeline will be constructed. By supplying 60,000,000 cu.ft. of additional gas a day it is expected that the annual output of these plants will be raised by 30,000,000 lb. Expansion of present facilities is desired where feasible but some additional plants may be required in order to reach necessary gas supplies in 1945. Expansion now under way will probably add 42,000,000 lb. of new capacity to which an additional 65,000,000 lb. will probably be added before the end of the year. Estimated production rate for next year is expected to be about 480,000,000 lb.

INSPECTORS WANTED FOR ARMY LABORATORIES

Base and mobile laboratories are being set up by the Army in several theaters of operation to check the quality of our own petroleum supplies and the suitability for our own use of captured enemy petroleum supplies. The laboratories also will check for sabotage of such supplies.

Petroleum inspectors and chemists who expect to be inducted into the Army within the next few months may apply for assignment to the laboratories which are designated Quartermaster Petroleum Products Laboratories. Applications should be forwarded to the Office of the Quartermaster General, Fuels and Lubricants Division, Technical Branch, Washington 25, D. C. Applications should contain information regarding education and experience, Selective Service board number, and the location and date upon which the prospective inductee is scheduled to report to his Selective Service board for shipment to a reception center, if this date is known.

ESSO CLUB OF ELIZABETH JOINS SIGMA XI

The first industrial research group to qualify and be granted affiliation with Sigma Xi is the Esso Club of Elizabeth, N. J., whose membership is drawn from chemists, physicists, engineers and other technical research and development personnel of the companies associated with Standard Oil Co. (New Jersey). Installation ceremonies were held in Elizabeth on April 26. The national officers of Sigma Xi and representatives of many local chapters attended the meeting. The executive committee of the Esso Research Club are: Minor C. K. Jones, Process Division, Esso Laboratories; E. W. Carlson, Chemical Products Laboratory, Standard Oil Co. of New Jersey; M. W. Swaney,

Chemical Division, Esso Laboratories; P. J. Gaylor, Research Division, Esso Laboratories; and R. G. Sloane, Public Relations Department, Standard Oil Co. (New Jersey).

FOOD TECHNOLOGISTS WILL MEET IN CHICAGO

UPWARD of 5,000 technologists from all parts of this country and Canada are expected to be present at the fifth annual meeting of the Institute of Food Technologists which will be held at the Edgewater Beach Hotel, Chicago, May 29–31. The meeting has been organized to cover three different aspects of food technology. The opening program will review developments since the last annual meeting. Speakers on the second day will concentrate on problems pertinent to the war effort. The third and final session will be devoted to a discussion of immediate and postwar problems.

At the annual banquet to be held on the evening of May 30, the Nicholas Appert Medal Award will be given to C. A. Browne, U. S. Department of Agriculture, Washington, D. C.

DRUG-PRODUCING CROPS IN CALIFORNIA

FURTHER experiments in the raising of drug producing crops will be made in California with the planting of correander, imported almost exclusively from Morocco before the war. Seed will be planted under the supervision of Monroe C. Kidder, head of the drug and oil plant branch of the State Department of Education. Besides being a powerful antiseptic, correander is used for flavoring and seasoning liquors and meats in Russia. Other new crops being raised in California are pyrethrum, cascara, peppermint, and licorice.

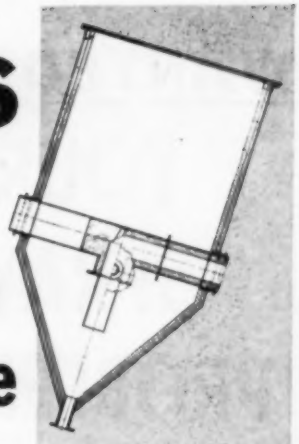
CHICAGO DRUG & CHEMICAL ASSOCIATION OFFICERS

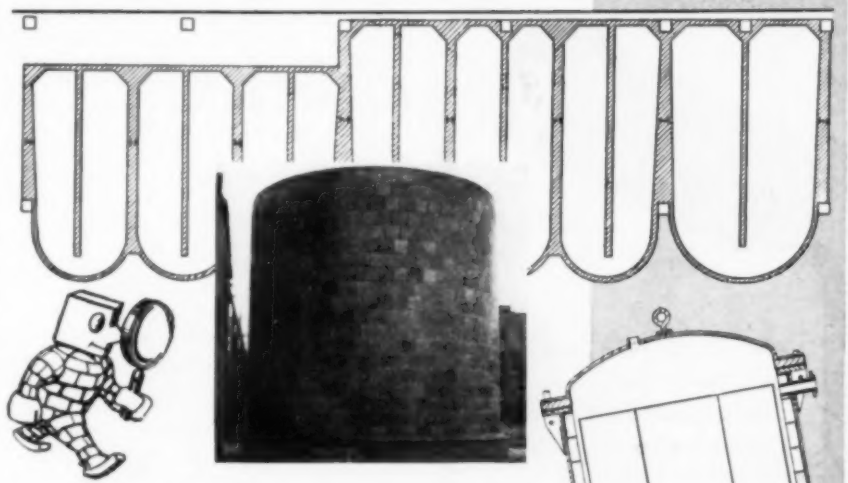
THE Chicago Drug & Chemical Association at its 44th annual meeting held in the Drake Hotel last month elected officers for the ensuing year as follows: F. Dean Hildebrandt, Hildebrandt & Co., president; Harry E. Dunning, Albert Verley & Co., vice president; Martin B. Vance, Givaudan Delawanna, Inc., secretary; and Edgar E. Brand, L. Sonneborn Sons, Inc., treasurer. The association will hold its annual spring party for members and their ladies in the grand ballroom of the Drake Hotel on the evening of May 20.

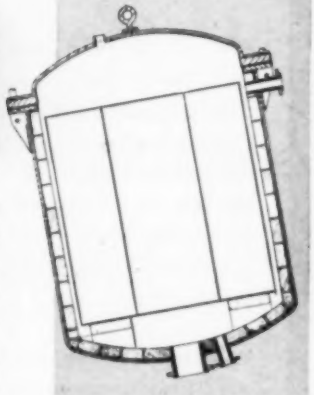
McGRAW-HILL OPENS NEWS BUREAU IN CLEVELAND

ESTABLISHMENT in Cleveland of a regional news bureau to serve the McGraw-Hill publications is announced by Harry M. Grinton, regional vice president of the company. The bureau will be headed by John M. Johnston, former Cleveland newspaperman. Mr. Johnston was graduated in chemical engineering from Vanderbilt University and took graduate work in chemistry at the University of Illinois.

60 YEARS
Lining and Tile Tank Experience Is At Your Service







During this period, we have successfully lined substantially every known type of process vessel, from the smallest plating tank to the largest acid storage tank; and from the smallest pickling vat to the most elaborate and complicated reactor.

You can benefit by this long and varied experience when planning your rehabilitation or modernization program.

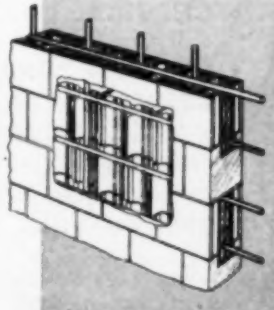
Every STEBBINS job is a "custom-built" job... designed to meet your individual operating and process requirements.

Every STEBBINS lining is constructed of materials carefully chosen to assure you a trouble-free, dependable and long lived installation.

Stebbins linings and tile tanks are installed in many of the outstanding chemical plants in the nation.

Every Stebbins job is covered by a lump sum contract, under which Stebbins supplies all required materials, all labor of installation and turns the completed lining job over to the customer ready for use.

One lining contract—one lining responsibility.



Stebbins Engineering and Manufacturing Company
367 EASTERN BOULEVARD, WATERTOWN, NEW YORK

WANTED:

YOUR SPRAY PROBLEMS!

Fig. F-80

Are all of your processes using Spray Nozzles as efficient as you think they could be? Do the Sprays distribute the liquid evenly? Break it up into as fine particles as you would like? Resist the corrosion or wear conditions satisfactorily?

Send Monarch an outline of any spray problem—If your liquid can be sprayed with direct pressure—Monarch can furnish the nozzles.

NOZZLES FOR:

- ACID CHAMBERS
- AIR WASHING
- CHEMICAL PROCESSING
- COOLING PONDS
- DESUPERHEATING
- GAS SCRUBBING
- HUMIDIFYING
- OIL BURNERS
- SPRAY DRYING

Do you have our Catalogs 6A and 6C?

MONARCH MFG. WKS, INC.
2730 E. WESTMORELAND ST.
PHILADELPHIA 34, PA.

NEWS FROM ABROAD

MANUFACTURE OF PLASTICS TO PROVIDE OUTLET FOR BRITISH COAL DERIVATIVES

Special Correspondence

THAT CONSIDERABLE attention is given to the manufacture of plastics as a stand-by in postwar days has been evident in many new developments in the British chemical industry. Several of the leading plastics producers have recognized their activities by amalgamating parallel productions and subdividing their work according to outlets. Several leading chemical and rayon firms have set up subsidiaries to engage in plastics manufacture, and so has at least one big paint maker. The association of plastics manufacturers has also adapted its organization to meet changed and more difficult conditions. Government agencies and research departments have carried out a great deal of valuable work, and the scientific associations have studied question of the plastics industry from another angle.

Yet it seems likely that the main stimulus to plastics production in Great Britain during the next few years will come from a different quarter. It is generally thought that owing to the reduction of overseas investments which was necessary to pay for the cost of war and owing to the likely contraction of income from shipping and other services, British industry will in future have to rely more on indigenous raw materials and in particular on coal, the country's principal natural asset, which promises to become the most important raw material of British chemical industry. The production of plastics is one of those industries which may be expected to absorb substantial quantities of various coal derivatives and thus help to make certain chemical productions of doubtful profitability pay their way.

At a recent joint meeting of the Association of Tar Distillers and the Plastics Group of the Society of Chemical Industry Dr. H. Levinstein gave the total amount of plastics raw material obtainable from coal on the basis of the last prewar production figures as 3,838,000 long tons. This includes 2,500,000 tons of methane in coal gas (which is now wasted as far as the chemical industry is concerned), 675,000 tons of hydrogen, 400,000 tons of ethylene, 220,000 tons of benzene, 30,000 tons of naphthalene, and 13,000 tons of phenol. For the utilization of methane for making methanol, formaldehyde, and methyl and methylene chlorides British experts refer to work now being undertaken in the U. S. A. and to the possibility of producing acetylene from methane by a recent process. The obvious source for

flexible **TABER PUMPS**

This "General-Use" Taber Centrifugal Pump serves especially well in the processing industry. It is flexible because there are several impellers for the same casing or one may secure several size casings for the same yoke... to make the pump easily adapted to many jobs. Oversize ball bearings, extra shaft diameter, deeper stuffing box. Helpful bulletin CLVS-339 on request.

Ad No. 5417

Please write on your letterhead.

Established 1859
TABER Pump Co.
294 ELM STREET
BUFFALO, N. Y.

methane in the British Isles would be the coal-gas and coke industry which in any case envisages a thorough reorganization and rehabilitation program, is likely to have more surplus gas when new coke ovens have been installed, and could be made to separate hydrogen and methane from commercial gas at, it is believed, little expense. If half the ethylene contents of coke-oven gas were recovered and converted into vinyl chloride, the plastics industry would possess another raw material source at a price it would gladly pay.

If demand for such gas as ethylene, propylene and butylene increases, a good case can also be made out for a revision of the official British policy with regard to oil refining. Were oil refineries with a capacity of 10,000,000 tons (still leaving several million tons of marginal and fluctuating demand to be met by imports of oil products obtained in insufficient quantities from home refineries) set up in the British Isles, a supply of about 1,000,000 tons of other than fuel materials for the use of chemical manufacturers would be available, and much of this would be useful to the plastics industry. Not only would these supplies make oil refining in British import harbors profitable, but they would help to fill gaps likely to arise in the event of exclusive reliance on coal derivaties. It is quite likely, for instance, that more naphthalene will be needed after the war than can be supplied by coal and tar distillers. This and other products could be provided by oil refineries which in the particular conditions prevailing in the British Isles might find it more profitable to burn coal or residues than to use low-grade petroleum fractions for that purpose and thus help to avoid accumulation of unsaleable byproducts.

Efforts have been made to bring coal-tar distillers and plastics manufacturers together to acquaint the former with the specific requirements of the synthetic resin industry and to make the latter material-conscious. Plastics producers have perhaps given too little attention to these questions because under peacetime conditions there was no raw material problem and in wartime supplies are allocated by the Control. As they are chiefly interested in cheap prices for their raw material, they may prefer to buy it abroad, while British coal producers and processors need the plastics market as an outlet for important byproducts. As an indication of possible future government policy it is interesting to note that the Controller of Tar Products in the Ministry of Fuel and Power in discussing anthracene, developed the point that "it is sometimes a very wise thing from the point of view of the national balance sheet to pay more for a product produced from indigenous materials."

Meanwhile government research stations study the question of plastics raw materials from coal and other carbon materials together with other investigations for the development of new outlets for coal. The plastics industry itself expects that the next few years will require vast expenditure, not only on new buildings and plants to take advantage of new developments, but to open and reopen markets at home and abroad and to promote research on a scale commensurate with the great needs

RYERSON STEEL IN STOCK

Call Ryerson for any kind, shape or size of steel you need. Steel for manufacturing, maintenance or construction ...all products are available for immediate shipment from any one of the ten convenient Ryerson Steel-Service Plants. Ask for a stock list...your guide to steel.

Principal Products Include:

Bars • Shapes • Structurals
Plates • Sheets • Floor Plates
Alloy Steels • Tool Steels
Stainless Steel • Screw Stock
Wire • Mechanical Tubing
Reinforcing Steels • Shafting
Babbitt • Nuts • Bolts
Rivets • Welding Rod • Etc.

JOSEPH T. RYERSON & SON, INC.
STEEL-SERVICE PLANTS AT: CHICAGO, MILWAUKEE, ST. LOUIS, DETROIT, CLEVELAND, CINCINNATI, BUFFALO, BOSTON, PHILADELPHIA, JERSEY CITY

Tractor Cranes—Pneumatic or Solid Tires. Trailer Trucks, All Types, All Sizes. Fork Lift Trucks. Elevators, Platform and Stacking. Conveyors. Hoists. Engineered and built to requirements.

MERCER-ROBINSON COMPANY, INC.
30 CHURCH ST., NEW YORK 7, N.Y.

Materials HANDLING Equipment

Equipment for processing, liquid and dry materials, foods, chemicals, reclaimants. Individual mixers, sifters, separators, crushers, cutters, mills. Combination units. Complete systems. Standard and engineered installations.

UNIQUE

Materials PROCESSING Equipment

How to CHECK WELDED SEAMS in Stainless Steel PROCESSING EQUIPMENT

Before "inducting" a new processing vessel into war work examine its joints and welded seams. For the life and strength and corrosion resistance of your equipment depends on the soundness of the welds.

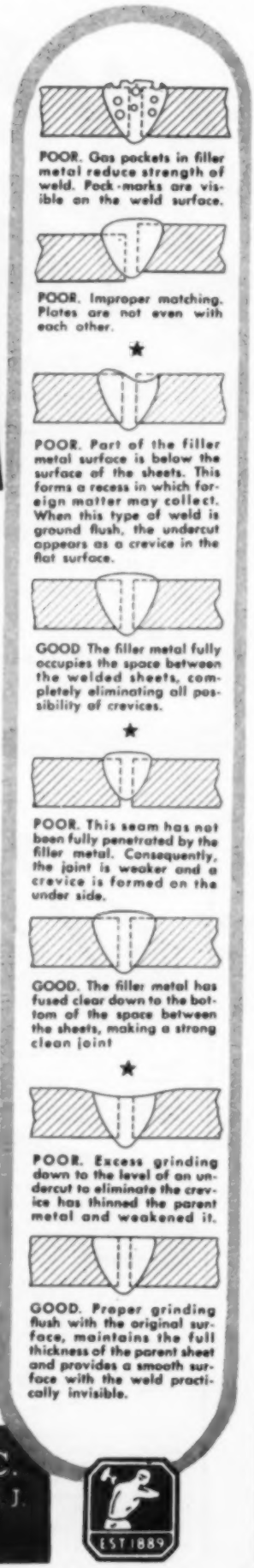
Improper welding can often be recognized with the naked eye. The diagrams at the right may serve as a guide to engineers in detecting proper and improper welds.

The most practical way to eliminate the danger of improper welding in your stainless steel processing vessels is to select a fabricator with specialized experience in working with this alloy. For years, S. Blickman, Inc., has devoted its large facilities mainly to the fabrication of stainless steel equipment in gauges up to ⅜" thick. Our *know-how* assures you of processing equipment with welded seams that stand up under wartime production.

All orders subject to Government priority regulations

ARMY E NAVY

These diagrams appear as part of the Blickman brochure "What to Look for When you Specify Stainless Steel for Your Processing Equipment" Write for the brochure on your company stationery.


POOR. Gas pockets in filler metal reduce strength of weld. Pock-marks are visible on the weld surface.
POOR. Improper matching. Plates are not even with each other.
POOR. Part of the filler metal surface is below the surface of the sheets. This forms a recess in which foreign matter may collect. When this type of weld is ground flush, the undercut appears as a crevice in the flat surface.
GOOD. The filler metal fully occupies the space between the welded sheets, completely eliminating all possibility of crevices.
POOR. This seam has not been fully penetrated by the filler metal. Consequently, the joint is weaker and a crevice is formed on the under side.
GOOD. The filler metal has fused clear down to the bottom of the space between the sheets, making a strong clean joint
POOR. Excess grinding down to the level of an undercut to eliminate the crevice has thinned the parent metal and weakened it.
GOOD. Proper grinding flush with the original surface, maintains the full thickness of the parent sheet and provides a smooth surface with the weld practically invisible.

S. BLICKMAN, INC.
800 GREGORY AVE., WEEHAWKEN, N. J.
TANKS • KETTLES • CONDENSERS • AGITATORS
• EVAPORATORS • PANS • VATS • CYLINDERS

EST. 1889

ahead. It has been suggested that some of the factories now used for the production of ammunition and other war products might be turned over to the chemical industry for peacetime needs including plastics manufacture. On the other hand, it is quite possible that a larger measure of cooperation inside the industry will be desirable than has been obtained in the early days when competition was not curbed by any exchange of knowledge or pooling of resources. Exports are at present confined to shipments for war purposes to the Dominions and allied countries.

At the recent shareholders' meeting of British Industrial Plastics reference was made to the outstanding part plastic products play in the production of the Mosquito, Britain's fast twin-engined plywood bomber which has been so conspicuously successful. The plywood is glued to the wooden framework by Beetle cements and itself bonded either with this material or a film composed of thin paper impregnated with a phenolic resin, the latter is cleaner and less wasteful but requires higher temperatures and greater pressures in application. Work is now under way to combine the advantages of both products so as to remove the drawbacks attached to either of them. Among other recent progress the company mentions improvements in the method of manufacturing molding powders as the most important development. When sufficient new plants can be added to those already available for the new process, great economies in cost of production and improvement in quality and consistency of shade (in the case of colored powders) will be effected. At the chemical factory one feature in the manufacture of melamine which threatened to be difficult has been solved. The company believes that its melamine process is the most effective and economical known in the world.

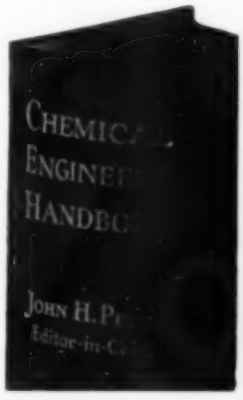
A process patented in England for the manufacture of melamine was described by W. Blakey. It is worked at atmospheric pressure, dicyandiamide being carefully fused with themostable guanidine hydrochloride (or other salt), and the latter not covered; the yield is 90 percent. The probable mechanism is partial depolymerization of dicyandiamide, followed by formation of a biguanidine salt which during heating dissociates into guanidine hydrochloride and nascent cyanamide, the latter mostly polymerizing directly to melamine and also partly combining with dicyandiamide to give melamine.

SWEDEN USES FURFUROL IN MAKING PLASTICS

FURFUROL, an important byproduct of the Swedish tanning-extracts industry, is being used more widely in that country in the manufacture of plastics. Because of shortages of methanol and phenol, furfurol is substituted for formaldehyde. It is stated that about 60 percent less phenol is required when formaldehyde is replaced by furfurol. The resulting plastic is satisfactory and much cheaper.

The shortage of insulating materials has caused concern in the Swedish electrical industries and this has led to the development of a plastic product which is said to compare with products formerly im-

Now available on
SMALL MONTHLY PAYMENTS



Perry's
CHEMICAL ENGINEERS HANDBOOK

2nd Edition, 3029 pages, 1300 illustrations, 1000 tables, $10.00

NOW you can start using Perry's new Handbook at once—paying in small monthly installments while you use it. No strings to the offer—no mark-up to cover installment charges—no difference in quality of the book. Just a special offer to urge action. Whether you are a practicing engineer, executive, plant or laboratory worker, or mechanical engineer—no matter what your question—whether directly concerned with chemical operations, or afield in such subjects as Plant Location, Report Writing or Fire Protection—you are sure to find it answered here—concisely explained and illustrated, authoritatively handled by a specialist, and instantly accessible.

30 big sections

Mathematical Tables: Weights and Measures
Mathematics
Physical and Chemical Data
Analysis, Qualitative Analysis, Catalysis, Organic Chemistry
Physical and Chemical Principles
Flow of Fluids
Heat Transmission
Evaporation
Humidification, Dehumidification, Cooling Towers, Spray Ponds
Gas Absorption, Solvent Extraction
Distillation
Crystallization, Sublimation
Drying
Handling of Material
Mechanical Separations
Crushing, Grinding, Pulverizing, Other Methods of Comminution
Measurement and Control of Process Variables
Materials of Construction
High-pressure Technique
Management and Storage of Materials
Piping
Power Generation, Mechanical Power Transmission
Refrigeration
Electricity, Electrical Engineering
Electrochemistry
Economic Factors in Chemical Plant Location
Accounting, Cost Finding
Safety, Fire Protection
Reports, Report Writing

10 days' Examination — Send coupon

McGRAW-HILL EXAMINATION COUPON

McGraw-Hill Book Co., 330 W. 42 St., N. Y. 18

Send me Perry's Chemical Engineers' Handbook for 10 days' examination on approval. In 10 days I will send $1.00, plus few cents postage, and $1.00 monthly for three months thereafter, or return book postpaid. (Postage paid on orders accompanied by remittance of first installment.)

Name .....
Address .....
City and State .....
Position .....
Company .....M. 5-44
(Books sent on approval in U. S. and Canada only.)

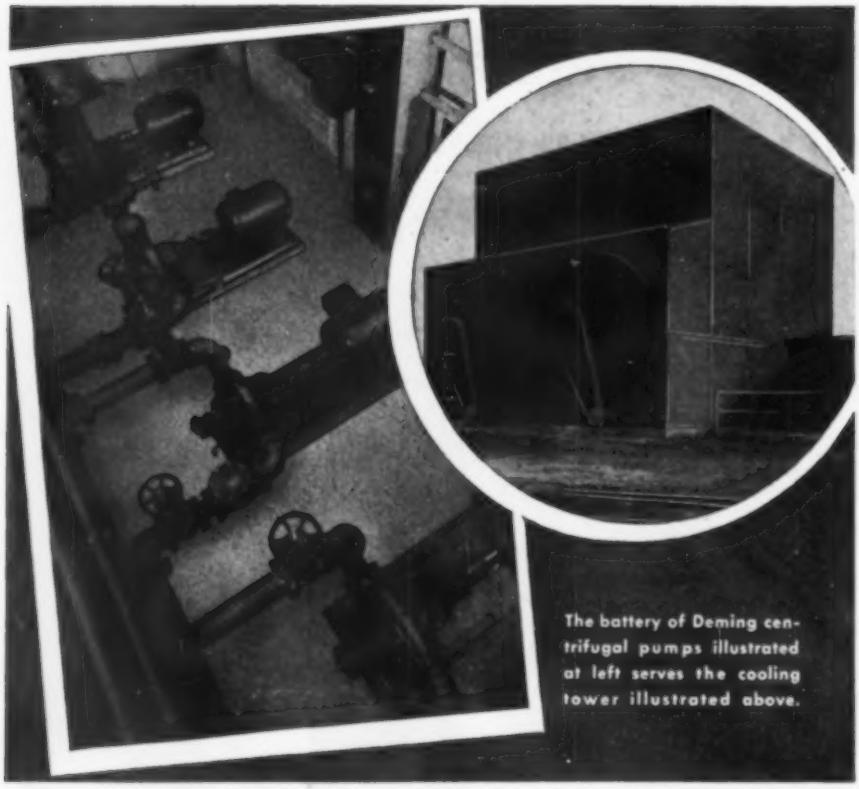
TO KEEP THE MACHINES OF PRODUCTION RUNNING AT THEIR

Most Efficient Speeds

When machine speeds are instantly and accurately adjustable, many problems in chemical processing are simplified, uniformity maintained and new production records established. In mixing, filtering, drying, pumping, proportioning, grinding and many other processes, REEVES Speed Control is widely used to compensate for variations in temperature, chemical reactions, weight, size, consistency of materials, etc. Perhaps you have a processing problem right now which accurate speed control will quickly solve. Send for copy of new 128-page Catalog G-435, which describes the REEVES Transmission, Motor Pulley and Motodrive and their use in chemical plants.

REEVES PULLEY CO., Dept. CM, COLUMBUS, INDIANA

Accurate-Variable **REEVES SPEED CONTROL**



The battery of Deming centrifugal pumps illustrated at left serves the cooling tower illustrated above.

"Repeat Performance"

Back in 1933, a Michigan manufacturer installed a "battery" of Deming Centrifugal Pumps for cooling tower service. The "battery" consists of two high head and two low head pumps, each rated at 1,000 gallons per minute.

Recently, the manufacturer decided to build a new cooling tower. Performance of the Deming Pumps after more than 10 years of service was so satisfactory that an exact duplicate of the original installation was ordered for the new cooling tower.

Many a "repeat performance" like that is a matter of routine record in Deming files. But those records offer PROOF that YOU can look to Deming and the Deming Distributor near you for the high standards of pump performance you demand for your operations.

Refer your pump questions to Deming for the right answers. The Deming Company, Salem, O. Distributors everywhere.

DEMING

THE COMPLETE LINE

PUMPS AND WATER SYSTEMS

The Deming Company · Salem, Ohio

ported. It can be made entirely from domestic materials.

ZINC ARSENATE USED MORE WIDELY IN SWEDEN

For some time Sweden has been confronted with the problem of finding new outlets for arsenic. Recovery of arsenic has run far ahead of consuming requirements and stocks continue to accumulate. Extensive research is in progress. Experiments with zinc arsenate have resulted in large use of this product in the insecticide field. It is being used to replace lead arsenate. It also may be used as a weed exterminator since it has been found a good medium for applying arsenic without injury to crops. Another use may be as an insecticide for forestry purposes.

CHEMICAL PLANTS TO OPEN IN SOUTHERN ITALY

According to press reports from abroad arrangements are being made to resume production at three chemical plants in southern Italy. Fertilizers are to be manufactured for use in liberated areas of the country. Essential raw materials for these plants will be imported under the direction of the Allied Control Commission.

GREAT BRITAIN NEGOTIATES FOR CHILEAN NITRATE

Reports from Chile say that negotiations are under way between the Chilean Nitrate and Iodine Sales Corp. and the British Government involving supplies of nitrate of soda for the United Kingdom. The report mentions 500,000 tons of fertilizer grade nitrate as the amount which may be shipped from Chile to Great Britain in the present year.

BRAZILIAN COMPANY WILL PRODUCE ALKALIS

According to a report credited to a foreign chemical journal, a company has been formed in Brazil to produce soda ash and caustic soda. The new concern is to be called Companhia Nacional de Alcalis. The address of the company and the probable site for the plant are not given but it is stated that the company expects to get into production within two years. Annual output is scheduled to be at least 25,000 tons of soda ash and 20,000 tons of caustic soda.

ECUADOR SOAP INDUSTRY MAKES PROGRESS

Production of soap in Ecuador has reached a stage where it is able to take care of the greater part of home requirements. The oils, which are the principal ingredient, are produced locally and most of the country's production of palma-real and coconut oils went to soap factories last year. Last year also brought the first important foreign competition as large amounts of soap were brought in from the Argentine. Despite high freight rates and import duties, the imported soap was sold at prices which local producers found difficult to meet.

CONSUMPTION OF SULPHURIC ACID IN PERU

REPORTS on the annual requirements for sulphuric acid in Peru place the total at 6,500 tons but do not specify whether this figure refers to the acid as consumed or whether it has been converted to a 100 percent basis. Production is in the form of byproduct acid supplied from copper-smelting operations by the Cerro de Pasco Copper Corp. at Croya. The corporation requires 3,000 tons for its own operations; an additional 2,500 tons are used locally for bleaching vanadium ores, and 450 tons in refining petroleum. The remainder is consumed in various Peruvian industries.

NEW CARDBOARD PRODUCTION IN VENEZUELA

A REPORT to the Department of Commerce states that a new cardboard factory was ready for operation in Venezuela in March. The plant has an estimated capacity of 20,000 tons a year but actual output is planned at about 5,000 tons in keeping with the present domestic requirements. The plant is a subsidiary of a firm in Caracas which manufactures finished paper products and is located at Petare not far from Caracas.

COCONUT SHELLS USED TO MAKE ACETIC ACID

A PILOT plant costing 300,000 rupees has been established by the Ceylon Government for the production of acetic acid from coconut shells. Utilization of shells for this purpose is expected to compensate in part for the serious decline of the coconut-shell charcoal market. The acetic acid industry may be able to absorb eventually about 500,000,000 shells annually.

MEXICO INCREASES OUTPUT OF ALCOHOL

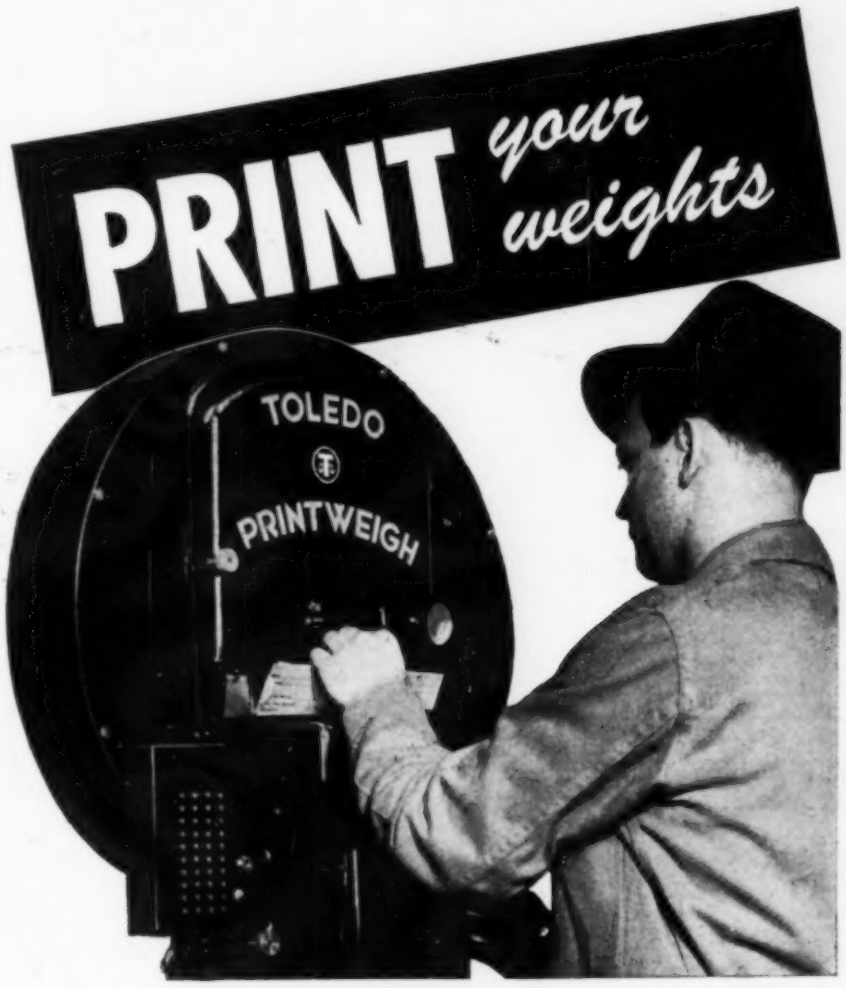
PRODUCTION of ethyl alcohol in Mexico has increased rapidly in recent years. The Sociedad Nacional de Productores de Alcohol reports production at 36,100,000 liters in 1942 which compares with 23,300,000 liters in 1940. The estimate for 1943 is 46,000,000 liters of which about 38,000,000 liters were made from molasses and the remainder from cane juice.

NEW PLANT IN FINLAND TO PRODUCE ALCOHOL

A NEW wood-saccharification plant is under construction at Heinola, Finland by Puukemia O. Y. When completed this plant will produce alcohol and later will undertake the manufacture of dextrose.

GERMANY USES ACETYLENE AS FERTILIZER

THE Axis press is authority for the statement that Germany has been experimenting with the use of acetylene as a fertilizer. The tests are reported to have been favorable and to have led to a decision to use acetylene for this purpose on a large scale.



STOP ERRORS
START COST RECORDS *RIGHT!*

● Bridging the gap between weighing and bookkeeping ...TOLEDO PRINTWEIGH gives you indisputably *accurate printed records* of each weighing operation.

Simple—even with green help, long hours, greater fatigue and wartime speed—PRINTWEIGH *keeps weight records straight.*

Rapid—puts accurate, printed weight records in the operator's hand with *split-second speed!*

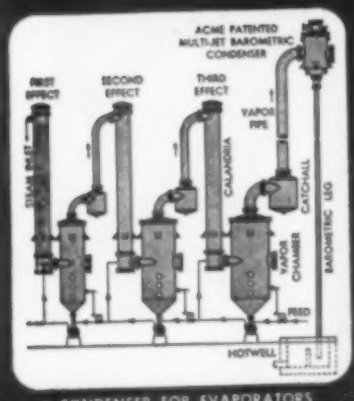
Dependable—prints BIG figures... *unmistakably big*... on thick tickets... on large or small sheets... on strips ... with extra copies.

Accurate—backed by more than 20 years of Toledo Research and Engineering in weight-printing. Thoroughly proved throughout industry, Printweigh is adaptable to scores of weighing operations. Toledo Scale Company, Toledo, Ohio... Sales and Service in 181 cities.

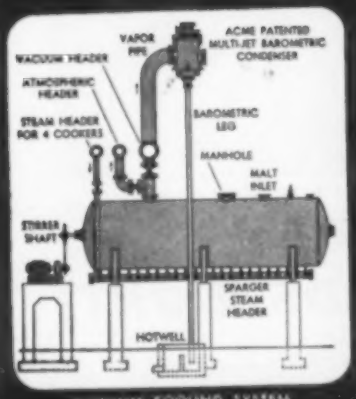
TOLEDO
PRINTWEIGH
SCALES

7 REASONS WHY...

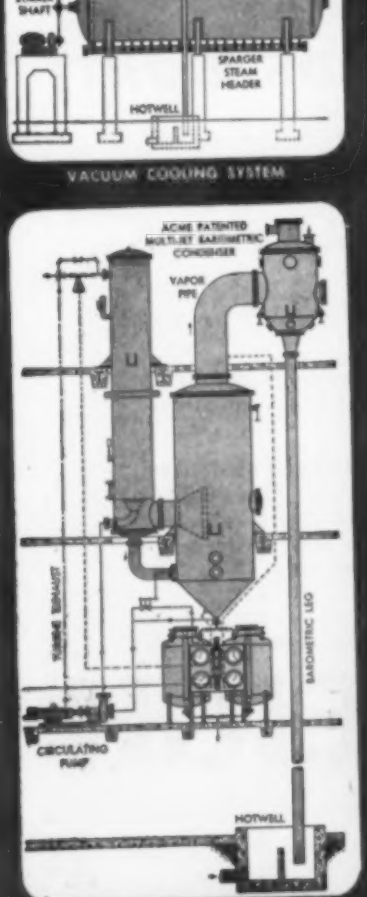
ACME *Patented* MULTI-JET BAROMETRIC CONDENSERS OPERATE WITH MAXIMUM ECONOMY!



CONDENSER FOR EVAPORATORS



VACUUM COOLING SYSTEM



CONDENSER FOR VACUUM PAN

Designed for vacuum processes where the condensate is not retained, the Acme Patented Multi-Jet Barometric Condenser combines the economies of both wet and dry operation. This patented unit offers the following exclusive features:

1. **COUNTER-CURRENT FLOW** that produces higher vacua (hitherto feasible only with dry operation).
2. **CONVERGING JETS** that expel the incondensible gases from the top of the condenser without the use of vacuum pump or ejector (the principal advantage of wet operation).
3. **A PATENTED SEAL** that prevents the escape of vapors until they reach the top of the condenser, thus making it possible to combine advantages (1) and (2) in one piece of equipment.
4. **POSITIVE CONTROL** of both involute and converging jets that attains maximum condensation at a minimum expenditure of water, even under fluctuating loads.
5. **LOW INITIAL COST** of equipment and installation.
6. **SIMPLE DESIGN** includes no moving parts, will not clog, and requires virtually no maintenance cost.
7. **CONVENIENT OPENINGS** for quick, easy inspection.

Bulletin MJ-44 "Acme Patented Multi-Jet Barometric Condensers" sent upon request

Where vacua over 27" Hg. are to be attained, we recommend the use of an Acme Counter-Current Barometric Condenser with suitable vacuum pump or ejector. The complete Acme line embraces every important type of condenser and ejector. Our engineers are prepared to study the requirements of any process and to make suitable recommendations for the most efficient operation.

ACME

Processing Equipment

ACME COPPERSMITHING & MACHINE CO., ORELAND, PA.

FROM THE LOG OF EXPERIENCE

DAN GUTLEBEN, Engineer

THE SUPERINTENDENT of a great boiler building outfit exhibited commendable ingenuity in the construction of an extension to the plate shop. He had fashioned a long row of columns and trusses out of the back yard accumulation of scrap which included tubes, shapes and plates. It showed that a practical superintendent can extract value out of a junk pile and effect a meritorious accomplishment without the assistance of a structural draftsman. During a recent visit from the Chief Engineer, the chronicler meted out some special praise of the superintendent's skill. The reply came with an approving twinkle—"Did Elmer tell you that after he finished the job we found a shortage in the new stock pile?"

ANTON JOHNSON, highly esteemed architect of Fresno, California, breezed into the chronicler's office in San Francisco early one morning about twenty-five years ago. He was on his way to the Capital City to submit to an examination for an architectural certificate. He had only a short time to catch his train and he needed letters from three contractors to certify to his moral and technological fitness for the exalted position to which he aspired. The two contractors having adjoining offices were out on their jobs and Anton had no other acquaintances. In this emergency, the chronicler borrowed letter heads from the neighbors and wrote the three letters, extolling Anton's outstanding qualities. The letters were signed by the respective secretaries and we bid Anton godspeed. The next day he returned with the official certificate in his pocket. Since then he has travelled a long way in his craft. A powerful impulse toward his early advance to fame and affluence was the circumstance of the Volstead Act. When the liquor traffic was politically outlawed, the vinyardists around Fresno became jittery. Many uprooted their vines. Some sold their vinyards for a song. Farsighted Anton bought one of these on a "shoe string" but had no money left for plowing up the vines. In the Fall an amazing thing happened. A great demand arose for wine grapes for home consumption. The price skyrocketed and Anton's farm paid 100% return before the year was out. The independent income set the youthful architectural mind at ease and thereby furthered unhampered progress towards his goal.

THE WPA FOREMAN who was in charge of the paving of Canal Street to the rear of the distillery two years ago, confessed to the chronicler that he was of Italian extraction and followed the custom of his forebears in personally manufacturing the wine for his own table. He requested to know if he could buy one of the old charred, rum-soaked barrels in which the rum had been aged for four years. The use of such a barrel would enhance the aroma of his product. The chronicler promptly promised to deliver a barrel with his compliments. However, it became necessary to break the promise as the Imperial United States Government demands a report on the disposition of every discarded alcohol barrel. The U. S. Gauger maintains a record of the traffic between the cistern room, bonded warehouse and rectifying plant and therefore cannot be hornswoggled.

GEORGE HOEPNER WAS GIFTED with surpassing skill as a builder of automatic scales. Furthermore, George exceeded all other sugar tramps in America in sharpness of temper. Around 1917 he was invited to furnish a trial scale to C. & H. He hailed this as an opportunity and accordingly ordered his shop not to stop short of the ultimate in quality of workmanship. Then he took the scale out to Crockett with the intention of erecting and operating it. While the erection was underway, he observed a competitor also erecting a scale alongside. Impetuously, irascible George removed his scale and returned with it to Chicago. Some time later, George's erector was in the neighborhood and adventitiously dropped in at the refinery and learned that the performance of the competitor's scale, together with a dozen more, was not satisfactory. The erector persuaded Crockett to let him have another trial with the Hoepner scale. After much argument, George also gave his consent but under the strict injunction that the erector would conduct the entire transaction without reference to himself. He would have nothing to do with the blankety blank outfit! In a short time erector Cullom had not only obtained satisfaction with the trial scale but had also replaced the entire lot of the competitor's machines with Hoepners. This installation of Hoepner scales was heralded far and wide for superior performance. The resulting publicity brought in the orders that kept his shop busy for years. Our plant purchased forty machines.

GEORGE NEVER SENT A BILL for his equipment until it performed satisfactorily. About twelve years ago, he offered to build a special soft sugar packer for us. It was to be built on the basis of "no work, no pay". After a number of months the machine was delivered and he proceeded to work with it. The performance was disappointing. About a week later, the chronicler went out into the packing room to see how he was getting along. There was the machine, smeared with soft sugar, but George was gone; and he hasn't been seen since nor has he ever answered our letters! The machine is still in the warehouse. In spite of his idiosyncracies, George possessed a delightful personality and his square dealing gave him entré into every sugar house in the land. He retired some years ago to practice gentleman farming in Illinois where he died last year.

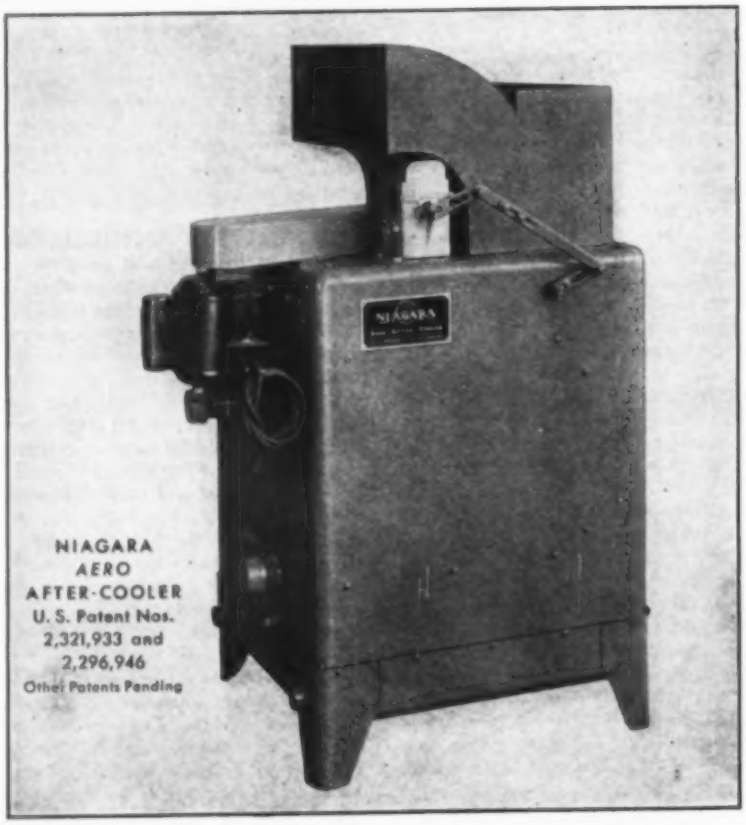
FITZ EXUDED ENTHUSIASM and promise in his eagerness to attain proficiency and the perquisites as steam plant operator. We provided him with a set of books and a free correspondence school scholarship. He possessed all of the essential qualities together with a surplus thirst which he avered was under control. His progress was rapid and satisfactory but the thirst inflated to such an extent as to require his release pro bono publico. When he left he "could not find" the books for return. However, five years later an ash man exhibited them with great pride, having picked them up in a pawn shop. The progressive dates of sale in the fly leaf indicated that the thirst advanced by increasing impulses.

JOE STETSUK started work with vigor and high hopes when he joined the shipping crew in '21. Every month he religiously remitted his wage to his wife and children in Poland. In '26 he was able to secure a passport for his family and he urged his wife to come over as he had made a down payment on a new home. She answered, "I have a man now." Joe wrapped himself in his ulster and jumped off the Delaware Bridge. He landed between two blocks of floating ice and was fished out by the Philadelphia fire tug. After six weeks' confinement in the city hospital he returned to the job. He grew melancholy and began hitting the booze. In '33 during a high heat wave, he collapsed and his body was sent to the morgue.

GUS SLACK of the machine gang was generally known for his exceeding frugality. In the days when work hours were legally unlimited and the pay in proportion, Gus worked 12 hours daily and usually elected to include Sundays. He had a farm in Michigan which functioned profitably under remote control. His Philadelphia domicile consisted of a single room with a gas stove and a sink where he operated bachelor-wise. Every harvest season he spent two weeks on the farm but always complained of the costliness. On one occasion it had required an outlay of $58.65. Nevertheless, he confided by way of consolation that his expense account included a small calf, a litter of pigs and a load of hay that he had bought from a neighbor.

A FAMOUS DISTILLER of a world renowned Cuban rum provides smart guides to conduct visitors through his plant. The guides are courteous and accommodating.

Keeping Water and Oil Out of COMPRESSED AIR



NIAGARA
AERO
AFTER-COOLER
U. S. Patent Nos.
2,321,933 and
2,296,946
Other Patents Pending

● Controlled temperature cooling with the NIAGARA *AERO* AFTER-COOLER has been the answer to excess water and oil in compressed air lines, preventing spoilage of material when compressed air is used in process and preventing damage to pneumatic tools. No refrigeration is required.

The NIAGARA *AERO* AFTER-COOLER both condenses the moisture before it gets into the lines and also provides jacket water of the proper temperature to prevent condensation in the compressor, washing out the lubricating oil.

It helps produce compressed air containing only ½ to ¼ as much moisture as air cooled by conventional equipment. At the same time it saves 95% of the cost of cooling water, pays for itself in a short time. Write for complete information.

NIAGARA BLOWER COMPANY

"25 Years of Service in Air Engineering"

NEW YORK Address: Dept. CM-54
6 E. 45th Street,
New York-17, N. Y.

Field Engineering Offices
in Principal Cities

NIAGARA

INDUSTRIAL COOLING • HEATING • DRYING
HUMIDIFYING • AIR ENGINEERING EQUIPMENT

and answer questions freely. It is told that a visitor once extolled the fine qualities of the much publicized "1873 vintage" and asked where it was made. This question was not in the guide's rote although willingness to inform had been a part of his training. After a slight hesitation, the guide's index finger pointed "right there" to a nearby still!

DR. HOOKER, the chemical wizard, supervised the operation of the beet sugar houses that came under the aegis of the Havemeyer interests around 1905. He used to send samples to the plants for the sugar boiler to match. Genial Manager Ferrar of Grand Island, Nebraska, with the General Grant beard, delivered his sample to the pan floor. The next day the sugar boiler brought the control sample and one of his own handiwork to Ferrar. Both were in identical trays with only a concealed mark. The sugar boiler dared Ferrar to distinguish between them. Ferrar balanced the samples respectively on his two palms and quick as a flash told the sugar boiler which one had been made in Grand Island. There existed in the two samples of sugars no difference detectable by the eye. Ferrar's keen wit is still a mystery to the artisan of the pan floor. The fact was that the sugar boiler in his impatience unwittingly omitted to cool his sample!

A CERTAIN SUPER-SALESMAN does not enjoy cigarettes. Nevertheless he finds it expedient occasionally to conform to convention. When he enters the sanctum of a native engineer in Calcutta he is offered a cigarette. Indian engineers do not smoke but the host knows that "all" foreigners do and so, for politeness sake, he passes out the cigarettes. The discreet salesman accepts, takes a few puffs and promptly proceeds with his mission. If he declines, his idiosyncracy requires explanation. This consumes time which he says ought to be spent in selling and not talking.

DOC WAS AMONG THE PIONEERS in the development of dry-ice manufacture. He was the first to deliver it in ton-lots for commercial exploitation. One of the Portuguese laborers attached to his plant in California took a small amount of it home in order to assist impressively at the evening party. He gave the guests a great surprize. With a mouthful of "snow" he exhaled a cloud of steam. His friends gaped with amazement but no one reached for the fire extinguisher, for after all, it was not their funeral. However, his wife, contemplating her proprietary interest, saved her husband by dousing him with a bucket of cold water. He was the life of the party!

AMONG DOC'S OTHER INTERESTS was the extraction of stock feed from the so-called wastes of the distillery. He heralded the virtue of his feed especially for the improvement of milk in quantity as well as quality. Every Portuguese had a goat in his back yard to convert domestic end-products into milk for the babies. A complaint came to Doc that one of the neighborhood goats delivered very sparingly in spite of the liberal use of his feed.

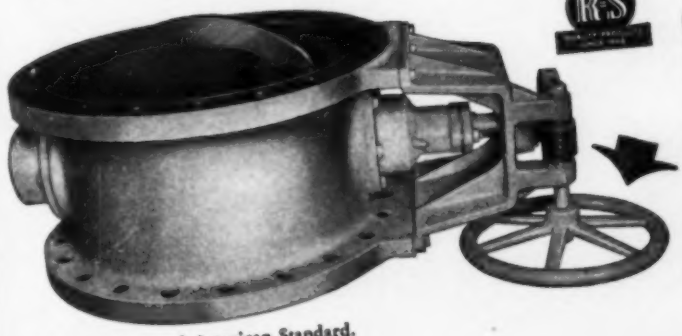
Doc did not believe it. In the early afternoon he slipped out of his laboratory for personal research. He found that the goat, having probably eaten some newspaper baloney about the superior dietary balance of the product of the great goat farms of California, had learned to contort herself into the milking position and extracted her own milk. She was on the way towards the solution of the secret of perpetual motion when her owner converted her into mutton chops.

THE TENANT FARMER on Doc's farm has 42 "scrub" cows that produce grade B-2 milk. A neighbor's herd, having 29 pure-bred cows, produces grade A milk. The dollar value of the grade B-2 milk from the scrub herd is exactly equal to the dollar value of grade A from the pure-bred herd. The maintenance of each cow, pure-bred or scrub, requires the crop of three acres of ground and is subject to the same operating overhead. The total capital investments in the two herds are comparable. Doc requested an explanation of the economics of his tenant's position. The answer was in the preponderance of the manure pile behind the barn; In chemical processes, like sugar refining, the desideratum is a high extraction coeficient of the base product. We have never experienced a desire to refine raw sugar valued at four cents per pound for the pleasure of producing end-product molasses worth eight cents per gallon and containing six pounds of sugar. Doc's tenant's argument compares with that of the laborer who refused a raise in wages on the ground that he would lose too much money whenever he took a day off.

CAMARADERIE among sugar house craftsmen is traditional. However, the rugged financiers of former years practiced rivalry that developed antipathy. Fraternizing among the men was condemned and this instilled a feeling of reserve. Nevertheless, under the great "welcome" sign of a popular Yonkers cafe, no questions were asked as to the precedence or antecedence of the guests. Here the craftsmen from the two local refineries were wont to congregate. A warming cocktail thawed out the frostiness and presently conversation swung to prohibited subjects. Peter Jenkins, Chief Engineer of Federal, was invited to inspect the new steam plant of the competitor—but nothing else! When Peter reached the boiler room, the host picked up the blue inspection glass, looked into the peep hole and was about to hand the glass over to Peter when a tongue of fire suddenly burst out from an exploded tube! The host ducked and flushed with chagrin. Peter repartced, "You needn't duck, Harvey, that was meant for me!"

SUBFOREMAN "SCHNAPPSPOPPY" brought in a heterogeneous gang on Sunday to bag the accumulation of black char dust. There were ten pale faces in his gang and two dark. When the Super came along and observed that one of the dark-faced attaches had a white bandage on his finger, he inquired about the cause. Schnappspoppy explained that he himself had applied the bandage to facilitate distinguishability.

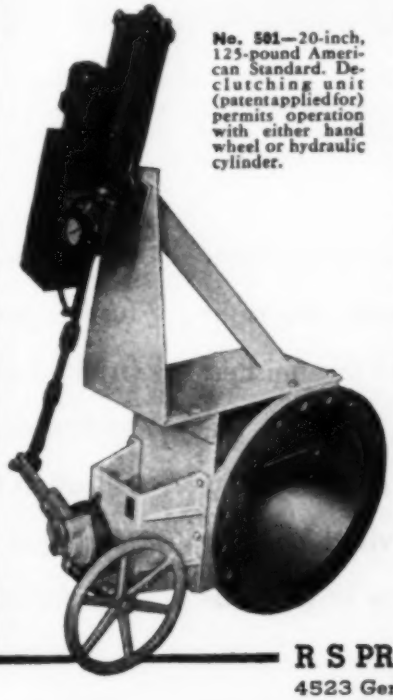
4 to 6 Hand Wheel Turns Open or Close Valve



No. 502—125-pound American Standard. Ball bearing mounted with stuffing box.

The quick operation of R-S Butterfly Valves is readily apparent. This is an important feature in any application but it is especially important where a battery of synchronous-driven pumps discharges into a common header. Burned-out motors at start-ups can be practically eliminated when R-S Butterfly Valves are installed, since it requires only a few seconds of an operator's time to shut off the discharge valves until the pump has gained the desired speed. The valves are then opened gradually, of course.

Equipped with hand wheel or chain wheel control, the standard 125-pound valves not only fulfill all requirements to better advantage, but cost less to purchase and install than conventional type valves.



No. 501—20-inch, 125-pound American Standard. Declutching unit (patent applied for) permits operation with either hand wheel or hydraulic cylinder.

NO SLAM—NO LINE DAMAGE

The 125-pound valve, equipped with hydraulic cylinder for power operation, prevents a synchronous-driven pump from grabbing all the load when the pump is started, prevents reverse flow and eliminates water hammer since the valve cannot move any faster than the bleeding of the cylinder discharge permits.

Straight-through flow—control and shut-off for any material that flows or is forced through a pipe.

Constructed in sizes to 84-inches and for **15 to 900 psi.** Write for Catalog No. 14-B.

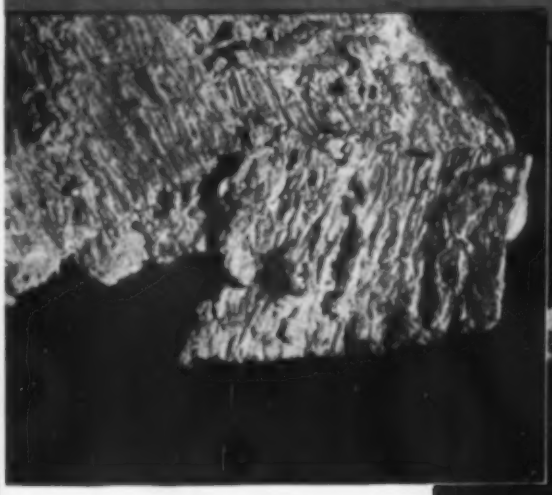
VALVE DIVISION

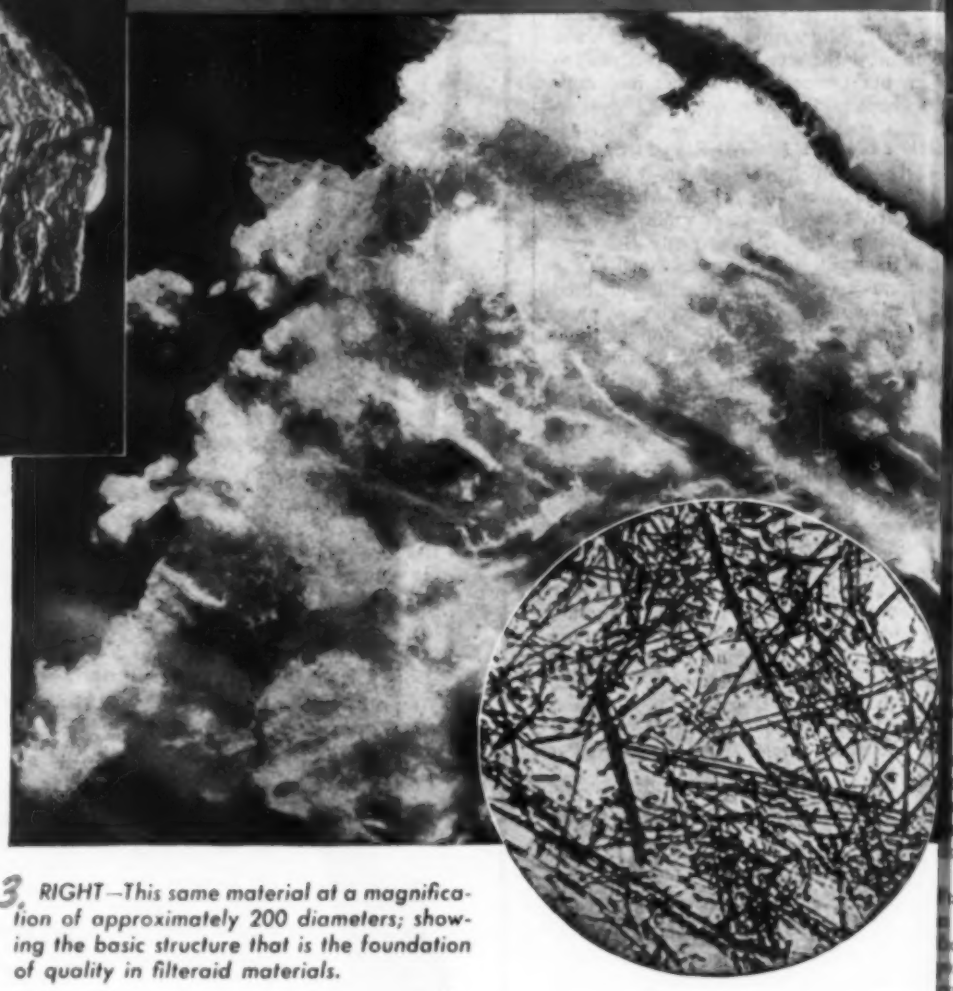
R S PRODUCTS CORPORATION

4523 Germantown Ave. • Philadelphia 44, Pa.

R-S Streamlined BUTTERFLY VALVES

Where Efficient, Low Cost Filtration Begin





1. ABOVE—NATURE'S ORIGINAL acicular pattern. Interesting formation of unrefined diatomaceous silica from one of the Dicalite deposits.

2. RIGHT—Same material fluffed up and enlarged approximately 7 diameters. The delicate, fleecy appearance denotes very light weight.

3. RIGHT—This same material at a magnification of approximately 200 diameters; showing the basic structure that is the foundation of quality in filteraid materials.

• Correct diatom structure is a vital necessity, and gives Dicalite filteraids the right "ancestry," yet the efficiency of the finished products depends equally as much on the refining process. The method of processing was developed and is supervised by men with many years of experience in the diatomaceous industry. Close laboratory contro further insures dependable performance— brilliant clarity, high flowrates, maximum fi tration output, and lower costs. A Dicalite Filtration Engineer will gladly assist in plan ning your future filter system, or help in cur rent filtration problems.

DICALITE FOR VICTORY

FILTERAIDS • FILLERS • INSULATION • ABSORBENTS • ADMIXTUR

THE DICALITE COMPANY

520 No. Michigan Ave., CHICAGO • 120 Wall St., NEW YORK • 756 So. Broadway, LOS ANGELES

JOBBERS AND OFFICES IN PRINCIPAL CITIES OF U.S.A. AND REPRESENTATIVES IN FOREIGN COUNTRIES

NAMES IN THE NEWS

Fred H. Haggerson

Howard R. Wilson

C. L. Knowles

ed H. Haggerson, vice president and director, was elected president of Union Carbide and Carbon Corp. at a meeting of the Board of Directors April 25. He will succeed **Benjamin O'Shea** who now becomes chairman of the board.

Winfred L. Norem has joined the research division of Cardox Corp. in the capacity of chemical engineer. Dr. Norem was formerly associated with the J-M Service Corp. **John Lee Ballard** has also been appointed as chemical engineer. Mr. Ballard was formerly an engineer with Fearn Laboratories in Chicago.

Frank E. Nabers has resigned his position as vice president and general manager of the Gager Lime Mfg. Co. to accept the position of vice president in charge of engineering of the Southern Ferro Alloys Co. of Chattanooga, Tenn. **Frank M. Ferguson** replaced Mr. Nabers on May 1.

Herman Hettinger, deputy, Domestic Branch, OWI, has resigned effective May 1. He was succeeded by **Brooks Darlington** who will continue to serve Petroleum Administration for War, Solid Fuels Administration for War, and Rubber Director.

D. D. Evans, formerly with New Jersey Zinc Co., and **E. A. Bruce** of Blaw-Knox Co., are among recent additions to the research and development department staff of Pennsylvania Salt Mfg. Co.

William A. Pennington has been added to the research staff of the engineering division of the Carrier Corp. Dr. Pennington will devote himself to metallurgical and chemical problems, including a number of research projects connected with the company's preparation of new and redesigned products for the postwar period.

R. Dixon of the Dow Chemical Co. has been appointed assistant manager of the company's plastic engineering division. Mr. Dixon has been with the Dow organization since 1936.

Howard R. Wilson has joined the research staff of Diamond Alkali Co. where he will function on projects involving unit operations, heat transfer, gas absorption, and equipment design, with offices at Painesville, Ohio. Dr. Wilson previously was with National Carbon Co.

J. K. Louden has been appointed production manager of the Glass and Closure plants of the Armstrong Cork Co.

W. W. Scull has been appointed manager of the synthetic rubber plant being operated at Port Neches, Tex., by the B. F. Goodrich Co. Mr. Scull joined Goodrich in 1929 and in his new position succeeds **W. J. Piggott** who has resigned to go into business for himself.

Harry E. Smith, general manager of the Manhattan Rubber Mfg. Division and **Robert B. Davis,** general manager of the Raybestos Division, have been elected vice-presidents of Raybestos-Manhattan, Inc.

D. J. Stewart, previously assistant general manager of Barber-Colman Co., Rockford, Ill., has been made vice president and general manager, succeeding **Earle D. Parker.**

Willard H. Dow has been selected to receive the gold medal award of the American Institute of Chemists for the year 1944.

Willis R. Whitney, honorary vice president of the General Electric Co. and first director of its research laboratory, has been made an honorary member of the Electrochemical Society.

Homer A. Holt, Ralph R. Browning and **Paul P. Huffard** have been elected to the board of directors of Union Carbide and Carbon Corp. Mr. Holt is a former governor of the State of West Virginia. Mr. Browning and Mr. Huffard have been associated with units of Union Carbide for more than 30 years.

C. L. Knowles has resigned from his position as manager of the Eastern Sales Division of the Dorr Co. Dr. Knowles left Dorr to accept the position of technical director of the Process Division of General American Transportation Corp. **Charles K. McArthur** has succeeded Dr. Knowles as manager of Eastern Sales for Dorr.

Marlin G. Geiger, presently a vice president and director of Westvaco Chlorine Products Corp., has been elected vice president and director of the United Chemicals, Inc. He will continue as resident manager of Westvaco South Charleston plant.

Winn W. Chase has resigned as executive editor of *Textile World* to become director of technical publicity and market research for Airdye Corp., Fair Lawn, N. J.

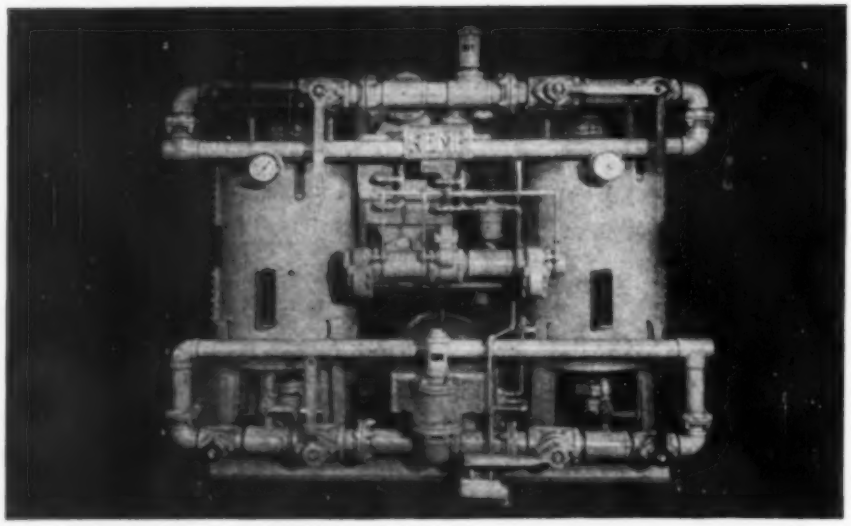
Harold Brayman has been appointed to be director of the Public Relations Department of E. I. du Pont de Nemours and Co. to succeed the late **Theodore G. Joslin.**

Hugh S. Taylor will succeed **Harold W. Dodds** as dean of the Graduate School at Princeton University. The appointment will take effect July 1945.

A. Vaughn Chinnock, who has been in the Research and Development Department of the Hooker Electrochemical Co. for the past four years, has been appointed to the Sales Development Department.

Raymond P. Allen has been appointed to the development staff of Sciberling Rubber Co. where he has been assigned to study and development of improved cotton, rayon and other fibers for use in tire carcasses.

Frank B. Allen, J. Stogdell Stokes and **Edward E. Simmons, Jr.,** have been awarded the Edward Longstreth Medal for meritorious work in science or the arts. Mr. Allen, of the Allen-Sherman-Hoff Co., receives the medal for his invention of



Whatever your drying problem...
KEMP HAS SOLVED IT BEFORE

K. S. G. silica gel adsorptive dryers are speeding forced draft production in every war industry* that faces problems in drying gases, liquids or solids.

Kemp Silica Gel Dryers are available on prompt notice in a wide variety of standard types and sizes, while specially engineered units to meet special requirements are furnished as quickly as war conditions permit. To summarize, standard units are made in capacities from ten to 100,000 c. f. m., from atmospheric pressure to very high pressures. Activation is by gas, electricity or steam as desired, with single tower units for intermittent operation or twinned towers for continuous production.

To paraphrase a famous (and living) U. S. General, standard units may be had RIGHT NOW, special designs will take a little longer. C. M. Kemp Mfg. Co., 405 East Oliver Street, Baltimore-2, Maryland.

***Except the dehydration of foods, which is a different problem altogether.**

KEMP of BALTIMORE

the "Seal Ring" used in centrifugal pum handling abrasive solutions; Mr. Sto for his development of paper box ma facturing machinery; and Mr. Simmons his invention of the SR-4 strain gage.

Arthur G. Wakeman, assistant direc of the Forest Products Bureau, WPB, resigned to return to Appleton, W where he is again actively engaged in paper industry. Prior to joining WPB March, 1942, Mr. Wakeman was nected with the Fox River Paper Cor

A. E. Drucker, dean of the school mines at Washington State College, retire in July after 18 years in his pre position. Dr. Drucker is widely kn for the prominent part he has taken in development of new extractive proce for magnesium and aluminum.

Neil A. Sargent has been appointed as ant research director of the Merrimac vision of Monsanto Chemical Co.

H. J. Rose, senior industrial fellow at lon Institute, has been made vice presi in charge of research of Anthracite In tries, Inc.

W. H. Henson has been appointed re tories field engineer by Norton Co., W cester, Mass.

J. W. Dietz, industrial relations man of the Western Electric Co.'s Manufac ing Department, who is at present leave for service with the Government, been awarded an honorary degree of do of engineering by Purdue University.

R. W. Thompson has been appointe rector of engineering for the General A ican Transportation Corp., its subsid and divisions.

Robert C. Harnden has been named i of the Dowicide Division of the Ins cides Department of the Dow Che Co.

D. H. Killeffer, chemical writer and lic relations consultant, has joined the of Hazard Advertising Co. to direct licity and public relations activities fo industrial clients of the agency.

Arthur D. Chambers has retired afte years service with E. I. duPont de mours & Co. In honor of Dr. Cham the dye works at Deepwater, N. J. been named the "Chambers Works."

J. C. Patrick, discoverer of Thiokol sulphide rubber, was elected cha of the Board of Directors of Thiokol C at the annual stockholders meeting 17.

Charles E. Staff has been appointe the Research and Development La tories of the Bakelite Corp. in Bloom N. J. Dr. Staff was formerly with C and Carbon Chemicals Corp. at S Charleston.

Thomas B. Dorris has been app chief chemical engineer for Sprout,

dron & Co. of Muncy, Pa. Dr. Dorris will be in direct supervision of the company's program for further development of equipment for the chemical and allied processing industries.

Bradley Stoughton retired April 15 from active teaching duty in metallurgy at Lehigh University. Prior to his service at Lehigh which began in 1923, he was secretary and executive officer of the A.I.M.E. and earlier was on the faculty of the School of Mines, Columbia University.

J. K. Gannett, vice president of the Austin Co. and its eastern district manager since 1928, has been appointed director of engineering in charge of engineering and research.

Alden H. Burkholder and **Emil Kline** have been appointed assistant research manager and chemical control manager, respectively, by Industrial Rayon Corp.

John Fairfield Thompson, executive vice president of the International Nickel Co., has been awarded the 1944 Egleston medal of the Columbia University Engineering Schools Alumni Association for distinguished engineering achievement.

OBITUARIES

Harry A. Linch, Engineering Department manager for the Dorr Co., died April 29.

Frank J. Cunneen, 53, Washington representative of Cochrane Corp., Nordberg Mfg. Co., and LeRoi Engine Co., died at his home in Washington April 7.

Lee E. Phillips, 67, co-founder of the Phillips Petroleum Co., died April 16.

P. M. Sharples, 86, founder of the separator manufacturing company which bears his name, died in California April 13.

George A. Orrok, 77, consulting engineer and widely known authority on power plant engineering, died at his home in Connecticut April 6.

Hugh W. Spaulding, secretary of Handy & Harman, died March 31.

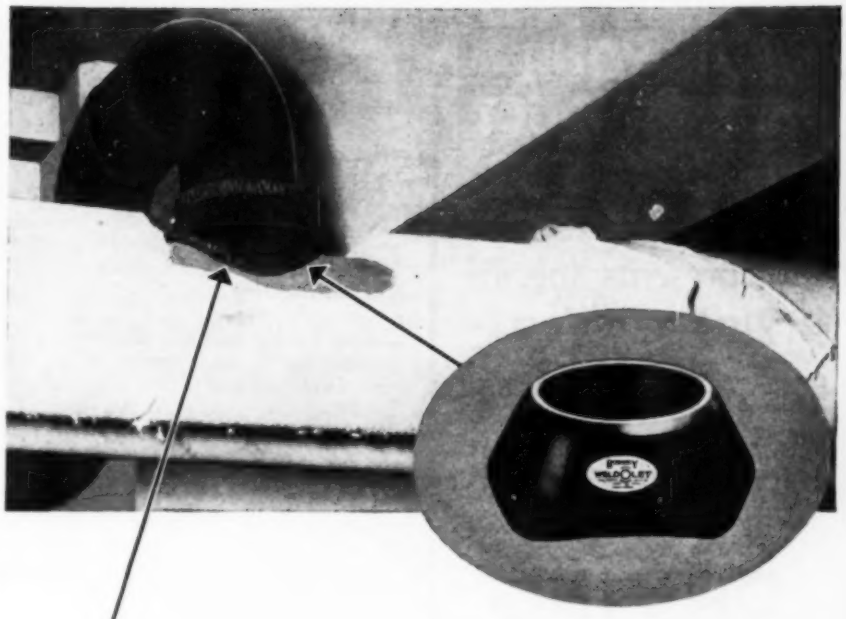
Roger C. Wells, 66, chief chemist of the United States Geological Survey, died April 19 in Washington.

Theodore G. Joslin, 54, director of public relations for E. I. du Pont de Nemours & Co. died in Wilmington April 12.

David Dorward, founder and head of Dorward & Sons Co., manufacturers of specially processed oils for paint, varnish and allied industries, died recently at the age of 65 in San Francisco.

John C. Brooks, 58, vice president and director of Monsanto Chemical Co. and general manager of its Plastics Division, died last month.

Georg Bredig, 75, died last April 24. Dr. Bredig, a physical chemist, had been in the United States since 1940.



By the WeldOlet method either gas or arc welding produces a branch pipe junction of full pipe strength. The steps are simple: Position fitting on main pipe; Weld solidly in place; Cut and remove the button; Attach the branch pipe.

How to make branch pipe outlets without cutting the main pipe

3 TYPES MEET EVERY NEED

WELDOLET— Beveled outlet for welded branch pipe connection.

THREDOLET— Threaded outlet for screwed connection of branch pipe.

SOCKET-END WELDOLET— Bored outlet to outside pipe diameter for welded branch pipe connection.

This is an extremely awkward place for a branch pipe outlet. But the installation was made quickly and economically by the WeldOlet method. A minimum of insulation was removed from the pipe—no templates were used. The main pipe did not have to be cut and the finished joint is as strong as the main pipe.

Thus, what is usually a time-consuming job is done quicker and more economically than by other methods. When you use the WeldOlet method, fittings are low in first cost, low in installation cost. Pressure loss is less because of the extra wide funnel shaped opening in the fitting where it joins the main pipe. Size-to-size and reducing sizes are available from ¼" to 12". For full information write for Branch Pipe Outlets Catalog WT31.

BONNEY FORGE & TOOL WORKS

Forged Fittings Division • **344 Green St., Allentown, Pa.**

WELDOLETS · THREDOLETS

For Welded Branch Pipe Outlets

FOR YOUR NEW PRODUCT OR PROCESS

that presents special drying problems—

apply the knowledge and experience of a quarter century that is possessed by

ROSS DRYING SPECIALISTS

Your product, old or new, can probably be improved with a ROSS Chemical Dryer, designed and built to meet your particular conditions and requirements.

Here's what we mean—

Your product might best be treated by ROSS Low Temperature Drying with dehumidified air —or

More efficiently handled in continuous ROSS Zone Controlled Ovens—or

Improved by heating air or other gases by means of ROSS Air Heaters.

Laboratory Testing

Our modern Testing Laboratory affords the most complete facilities for determining correct conditions for treatment of your product.

J. O. ROSS ENGINEERING CORPORATION

350 Madison Ave., New York 17

CHICAGO 6 201 N. Wells St. | DETROIT 3 12953 Greeley Ave.

ROSS ENGINEERING OF CANADA Ltd., Montreal

INDUSTRIAL NOTES

H. K. Porter Co., Inc., Pittsburgh, has placed Joseph F. Gaffney in charge of its office in Rochester, N. Y.; R. W. Steves in charge of the Cincinnati office; and W. T. Campbell in charge of the Philadelphia office. J. L. Cunningham has been appointed field service engineer for northern New Jersey with headquarters at 340 Thomas St., Newark.

Empire Equipment Corp. Cleveland, with headquarters in the Empire Bldg., has been formed to deal in new and used machinery and steel storage tanks. James H. Nolan and A. S. Brien head up the new company.

Copperweld Steel Co., Warren, Ohio, has promoted N. H. Brodell to the office of district manager at Cleveland. He was formerly metallurgical sales engineer for the company.

United States Rubber Co., New York, announces that the New England branch office of Dispersions Process, Inc. and the Naugatuck chemical division has been reopened at 560 Atlantic Ave., Boston with S. Brown in charge.

Reichold Chemicals, Inc., Detroit, has elected M. W. Reece vice president in charge of Pacific Coast operations. Mr. Reece will have general managership of the manufacturing plant at South San Francisco and will supervise activities of the branch offices at Los Angeles and Seattle.

General Aniline & Film Corp., New York, announces the appointment of Charles F. McKenna as manager of its special products sales division to succeed Roger Coleman.

U. S. Industrial Chemicals, Inc., New York, announces the resignation as of April 14, of A. J. Wittenberg, vice president of the company and director of the Stroock & Wittenberg division.

Victor Chemical Works, Chicago, announces that Harley B. Hobbs, sales and advertising manager, resigned on May 1 to become associated with the advertising agency of Cruttenden & Eger, Chicago.

Heyden Chemical Corp., New York, has promoted John Paul Remensnyder to the office of vice president in charge of sales. He succeeds George Simon who has retired.

Carrier Corp., Syracuse, announces the retirement because of ill health of R. L. Tomlinson for 21 years manager of the marine department. Leo Starr and J. R. Lewis have been appointed sales manager and operations manager respectively.

LONERGAN VALVES . . . ON GUARD

When unsafe over-pressures develop, dependable Lonergan relief valves are on the job . . . guarding pressure systems on hundreds of Navy and merchant ships . . . ready for the instant when pressures may get out of hand.

The Model "WTN-W" illustrated at the left is one of many types of Lonergan relief valves. Lonergan will welcome the opportunity to submit recommendations on the right valve for your particular application.

Model "WTN-W" Relief Valve
A top guided, high capacity, liquid or vapor relief valve, available in standard sizes up to 6"; in both iron and steel body types. Trim to suit service. This valve is noted for efficient day-in-day-out dependability, and low maintenance cost. For pressures up to 600 lbs. per sq. in.

J. E. LONERGAN CO.
Lonergan pressure gauges are "easy to see"—modern, easy-reading dials. They are properly designed, precision-made, and maintain accuracy over long periods of time. Made in all types . . . for hydraulic, steam, air, oil and chemical services.

Lonergan

J. E. LONERGAN COMPANY, 2nd & RACE STS., PHILA. 6, PA.

SAFETY VALVES • RELIEF VALVES • PRESSURE GAUGES • SPECIALTIES

HOW aviation gasoline is composed manufactured tested

Chemists and engineers will get from this book the facts to fill any gaps in their knowledge of the properties of the components of this fuel—plus a practical view of the various manufacturing processes, including chemistry, flow patterns, elements of operation, yields, and other pertinent aspects.

Just Published

AVIATION GASOLINE MANUFACTURE

By MATTHEW VAN WINKLE

Instructor in Chemical Engineering, University of Michigan

Pennsylvania State College Mineral Industries Series. 275 pages, 5½x8½, 39 illustrations, 82 tables, **$3.00.**

HERE is your guide to the relatively new field of aviation gasoline manufacture, reviewing the theoretical and technical essentials of the many processes now producing this type of fuel commercially.

It covers:

- specifications and test methods and their relation to the production of aviation fuel
- the pertinent properties of the materials that compose the fuel, the stocks to be synthesized, and the blending materials
- the manufacture of base stocks suitable for blending finished aviation fuels
- the processing and the relationship of the various conversion methods generally, followed by description of the actual processes used in the refining industry
- the combinations of the various processing elements to produce satisfactory aviation gasolines and the effects of the individual components on the finished gasoline
- special aviation fuels and blending components, such as ethers, ketones, and high-flash aviation fuel

In sections on testing, the book brings out the significance of specifications for aviation gasoline, the value of tests for both producer and user, laboratory and performance methods of testing, etc.

This new book brings together the facts necessary to an up-to-date and working knowledge of this specialized field—presents the fundamentals, methods, illustrative data, references, and other material that will be of value to the investigator and engineer.

See it free — Mail this coupon

McGRAW-HILL ON-APPROVAL COUPON

McGraw-Hill Book Co., Inc., 330 W. 42nd St., N. Y. 18

Send me Van Winkle—Aviation Gasoline Manufacture for 10 days' examination on approval. In 10 days I will send $3.00 plus few cents postage, or return book postpaid. (We pay postage on orders accompanied by remittance.)

Name .....

Address .....

City and State .....

Position .....

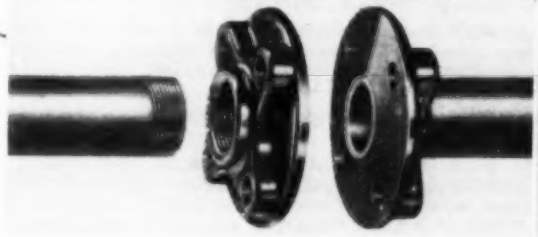
Company .....M. 5-44

(Books sent on approval in U. S. and Canada only.)

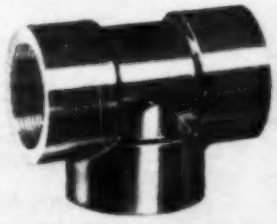
PLASTIC Pipe, Tubing and Fittings

Now Available from GRINNELL

Keeping abreast of new developments in the piping field, Grinnell now offers Plastic Pipe, Tubing and Fittings for the various applications where its special advantages provide improved performance and economy.



SARAN PIPE
½" to 4" I.P.S.



SARAN Screwed FITTINGS (Molded)
½" to 2" I.P.T.

Welding FITTINGS (Fabricated)
½" to 4"

SARAN TUBING
⅛" to ¼" O.D.

CELLULOSE ACETATE TUBING
⅛" to 2" O.D.

SARAN S.A.E. Flared FITTINGS (Molded)
⅛" to ¾" O.D. Tube Sizes

Write or call the Grinnell office nearest you.

GRINNELL

WHENEVER PIPING IS INVOLVED

GRINNELL COMPANY, INC.
Executive Offices, Providence 1, Rhode Island

SALES OFFICES

Atlanta, 2, Ga.
Charlotte, 1, N. C.
Chicago, 9, Ill.
Cleveland, 14, Ohio
Houston, 1, Texas
New York, 17, N. Y.
Minneapolis, 15, Minn.
Philadelphia, 34, Pa.
St. Louis, 10, Mo.
St. Paul, Minn.

"Buffalo" Wire Cloth Is Shipped READY FOR PRODUCTIVE USE

FINISHED TO YOUR SPECIFICATIONS FABRICATED INTO COMPLETED PRODUCTS

Strainers, baskets, filters, screens—hundreds of varieties—are moving through the "Buffalo Wire" plant. Close tolerances, accurate sizes, difficult shapes—such are the specifications demanded for tanks, ships and planes.

To a large group of America's war industries—synthetic rubber, chemical, process, oil refining, powder, abrasives—"Buffalo Wire" is delivering wire and metal products **ready for productive use.** No doubt your plant, too, can make profitable use of these broad services:

Complete details in FOLDER 594
A free copy belongs in your files.

TRIMMING, SLITTING, CUTTING
to accurate dimensions on power squaring shears of great capacity. Economical cutting of large and heavy grades of material.

DIE-CUTTING
any shapes or circles on punch presses and stamping machines.

SHAPING
forms of various depths.

BINDING
with webbing and sheet metal edging.

SOLDERING
several types of cloth into single panels.

WELDING FABRICATION
of all types and weights of materials. Spot welding by most modern, electronically controlled machines. Also arc and gas equipment.

GALVANIZING
Hot Dip process assures thorough coating of hot spelter to protect wire cloth and fabricated products against rust or corrosion.

SPRAY AND DIP PAINTING

TECHNICAL SERVICE
for practical assistance in wire cloth and fabrication problems.

RUSH
SUB CONTRACT AN 62904 AA1
TO America's War Industries
CONTENTS-METAL PRODUCTS
FUEL STRAINERS, WIRE SCREEN FOR EXPLOSIVES and WAR CHEMICALS, ALL TYPES OF WIRE CLOTH, BASKETS, GUARDS, LOCOMOTIVE STACK NETTING, FABRICATED METAL PARTS
FOR
• CARGO PLANES
• TANK DESTROYERS
• TANKS
• WARSHIPS
• MERCHANT SHIPS
• SUBMARINES
• LOCOMOTIVES
• FOOD INDUSTRIES
DOING BUSINESS FROM COAST TO COAST FOR 74 YEARS
Buffalo WIRE WORKS CO., INC.
ESTABLISHED 1869 AS SCHEELER S SONS
482 TERRACE BUFFALO 2, N. Y.

E. I. duPont de Nemours & Co., Inc., Wilmington, has changed the name of its Dye Works at Deepwater to Chambers Works. This change was made to honor Dr. Arthur Douglas Chambers who was instrumental in founding the works 26 years ago and who recently retired after 47 years of company service.

Westinghouse Electric & Mfg. Co., East Pittsburgh, has named Quincy M. Crater assistant manager for the Detroit territory. He was formerly manager of the petroleum and chemical section of the industrial department. J. K. B. Hare is central district manager.

The Timken Roller Bearing Co., Canton, Ohio, has placed James F. Reid in charge of production of its steel and tube division. Mr. Reid had been serving as deputy chief of the alloy steel branch of the War Production Board.

The Allied Asphalt and Mineral Corp., New York, has reorganized its production, research, and sales departments. All manufacturing is now under the supervision of Glenn P. Smith; Samuel C. Robinson is in charge of research and development work. Daniel D. Downes is director of sales. The wax and oil division continues under the direction of Heinz H. Kraaz.

Link-Belt Co., Chicago, has opened a sales office and warehouse at South 151 Lincoln St., Spokane, Wash. Homer A. Garland is in charge.

Yale & Towne Mfg. Co., New York, has purchased the scale business of the Kron Co., Bridgeport, Conn. The facilities and personnel of the Kron company will be maintained but all will be under the general direction of the Philadelphia division of Yale & Towne.

Dugas Engineering Corp., Marinette, Wis., has appointed Clifford H. Wyman sales manager. He had been serving as manager of the district office in Chicago. The corporation also is now sharing offices at 61 East 42nd St., New York, with the Ansul Chemical Co.

Bailey Meter Co., Cleveland, at organization meeting, elected E. G. Bailey as chairman. He is the founder of the company and formerly served as president to which office he is succeeded by Robert S. Coffin. Other officers are R. E. Woolley, vice president and J. H. Black, secretary-treasurer.

Monsanto Chemical Co., St. Louis, has moved C. G. Gress, formerly manager of the Detroit office of the plastics division, to Springfield, Mass., where he will act as sales manager of the Resinox department. Carl Whitlock has been named manager at Detroit in charge of all plastic materials sales in that area.

Alloy Casting Co., Champaign, Ill., has appointed Roger F. Waindle, general manager and chief engineer. Formerly he was chief of tank and automotive production for the War Department, Chicago Ordnance District.

The Selas Co., Philadelphia, has added J. S. Egea to its staff. Mr. Egea takes over sales engineering representation on the West Coast with headquarters at Los Angeles.

Amend Drug & Chemical Co., Inc., New York, was recently formed by a group long associated with one of largest drug, chemical and apparatus supply houses in New York. E. P. Amend is president of the new company and E. B. Amend vice president. The company has a plant at Lodi, N. J.

Metal Salts Corp., Hackensack, N. J., is the name of a new company formed to operate in the metal salt field. Wm. M. Rich has resigned as director and vice president of F. W. Berk & Co. to become president.

Drill Equipment Co., New York, on May 1, moved its offices to larger quarters at 225 West 34th St. The company's warehouses and shops also have been moved to 2401 Third Ave.

The Sherwin-Williams Co., Cleveland, has appointed B. M. Van Cleve general manager of its pigment, chemical and color division with headquarters at 295 Madison Ave., New York. T. H. Zappert succeeds Mr. Van Cleve as New York manager of the division.

C. J. Tagliabue Mfg. Co., Brooklyn, at a recent meeting, elected A. F. Rucks president and general manager to succeed the late C. D. Waters. Mr. Rucks has been associated with the company for more than 30 years.

Cutler-Hammer, Inc., Milwaukee, has made G. E. Hunt acting manager of the company's Atlanta territory with offices and warehouse at 134 Marietta St., N. W., Atlanta.

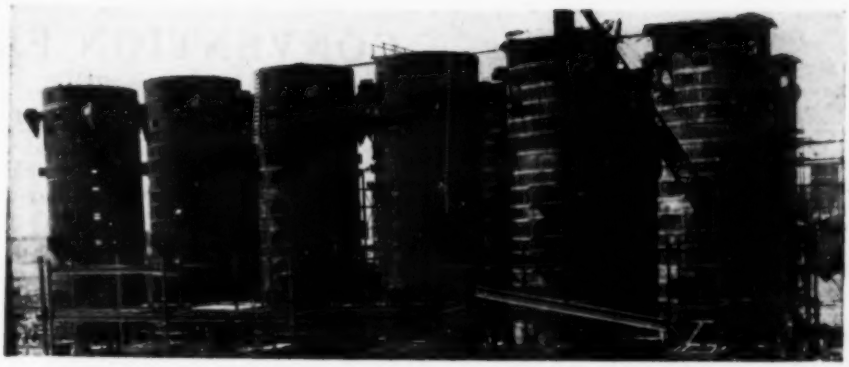
Harnischfeger Corp., Milwaukee, has appointed E. W. Potratz manager of the hoist sales division.

Foster D. Snell, Inc., Brooklyn, has purchased the National Calibration Service of the same city and will operate it as a separate department of the Snell organization.

Temco Corp., Baltimore, has added R. L. Foraker and S. S. Groglode to its sales staff. The corporation also has advanced O. L. Davis from purchasing agent to works manager and placed James Theodore in charge of purchases.

The Marley Co., Inc., Kansas City, Kan., is now represented in the Tulsa territory by Walter S. Smith and his Process Equipment Co. Joe T. McKinley has been sent from the main office to the office recently opened in Houston.

Stearns Magnetic Mfg. Co., Milwaukee, announces that Stanley L. Burgess has rejoined the company having been released from the army air forces. Mr. Burgess will act as sales representative in the Detroit area with headquarters at 6432 Cass Ave., Detroit 2.

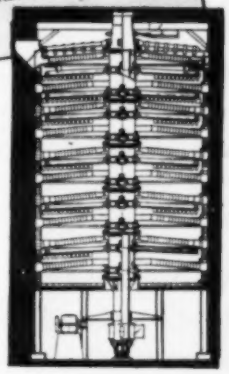


NICHOLS HERRESHOFF MULTIPLE HEARTH FURNACES OFFER A PRACTICAL SOLUTION TO SPECIFIC THERMAL PROCESSING PROBLEMS

1 — Nicaro Nickel Company has installed 12 Nichols Herreshoff Multiple Hearth Furnaces for roasting limonite and serpentine ores for the economical production of NICKEL.

2 — Basic Magnesium, Inc. uses 4 Nichols Herreshoff furnaces for the first step in the production of MAGNESIUM from carbonate ore.

3 — A typical Nichols Herreshoff Multiple Hearth Furnace. Known the world over for economical and efficient thermal processing of many materials.



NICHOLS HERRESHOFF Multiple Hearth Furnaces because of their flexibility of design, compactness, small space requirements and low power consumption have established remarkable performance records in the processing of many materials. Thousands of furnaces have been installed to process ZINC, COPPER, IRON, MOLYBDENUM, TUNGSTEN, MERCURY, QUICKSILVER ores and concentrates, etc.

The benefits of fifty-five years of experience in designing and constructing furnaces for roasting, calcining and drying are at the disposal of engineers having specific processing problems.

NICHOLS ENGINEERING & NERCO RESEARCH CORP.

60 WALL TOWER BUILDING
NEW YORK 5, N. Y.

UNIVERSITY TOWER BLDG.
MONTREAL, P. Q.

NEWARK for ACCURACY

TESTING SIEVES
That Report True Facts

We can think of numerous test operations where the precision of screening is fully as important as accuracy in chemical or fire analysis.

Test sieves are key equipment in the control laboratory. They should be the best obtainable. The strongest. The most durable. With the highest maintained accuracy.

What have NEWARK Testing Sieves to offer? Cornerless—with no crevices between cloth and frame to catch particles. All soldering outside—to facilitate cloth removal. Cloth attached directly to the sieve frame—not to an extra rim—to prevent distortion and maintain unform tautness. Strongly built frames.

These are useful characteristics of NEWARK Testing Sieves.

NEWARK WIRE CLOTH CO.
350 VERONA AVE. NEWARK 4, N. J.

CONVENTION PAPER ABSTRACTS

PENICILLIN MOLD DIET

PENICILLIN, important as it is today, was not produced in sufficient quantities to make it of interest to commercial manufacturers until scientists in the Northern Laboratory greatly increased the yield by feeding the mold on a diet of agricultural products. The scientists tried feeding the mold on a diet made from corn steeping liquor, a byproduct obtained in the manufacture of corn starch. The mold liked the new diet so well that the yield of penicillin increased a hundredfold in a short time. The scientists found also that the mold did well when fed on lactose sugar which comes from cow's milk—another agricultural product. The agricultural diet is being used today by the 15 or more companies that are now manufacturing penicillin on a commercial scale and will probably be used as long as penicillin is produced by a mold.

The production of penicillin has increased from 425 million units in June 1943 to more than 18 billion units in February 1944, and the price has dropped from $20 to $3.25 per 100,000 units—a reduction of 84 percent in a year. It is estimated that the $20,000,000 worth of plants that will be producing penicillin by the end of this year will have a capacity of about 9 lb. of pure penicillin per day, enough to treat 250,000 serious cases per month.

R. D. Coghill, Northern Regional Research Laboratory, before American Chemican Chemical Society, Cleveland, April 5, 1944.

AMMONIUM FERROUS PHOSPHATE IN PAINT FINISHES

IN A search for new pigment materials to improve the performance of metal-protective paints the behavior of ammonium ferrous phosphate ($NH_4FePO_4H_2O$) has been investigated. This is an insoluble, greenish compound possessing a platelike structure and a characteristic x-ray diffraction pattern.

Evaluation of the product to date by various methods, including conventional panel tests, has indicated that a definite improvement in performance can be obtained by its use in certain types of primer systems. Tests designed to demonstrate behavior under severe conditions of moisture condensation have likewise indicated its value, especially in ferrous metal primers of the zinc yellow type.

The mechanism of the action of ammonium ferrous phosphate has not been positively established but it is suggested that it probably functions both as an acid acceptor and oxygen acceptor and at the same time improves the impermeability of the film to water vapor by reason of its flake structure.

A. M. Erskine, G. Grime and S. C. Horning, Pigments Dept., E. I. duPont de Nemours & Co., Newark, N. J., before Division of Paint, Varnish and Plastics Chemistry, American Chemical Society, Pittsburgh, Sept. 6, 1943.

CURRENT ZINC OUTLOOK

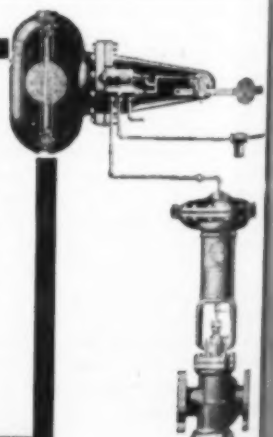
AS FAR back as 1941, it was evident that our zinc smelting capacity was inadequate for the increasing demands imposed upon our economy by the advent of the European War. This was particularly true of high-grade zinc. As an indication of the progress made we can make this comparison. Of the 80,000 tons produced in March 1942, approximately 38,000 tons was special high and high grade zinc. By May 1943 the production of these grades totaled 53,000 tons or an increase of nearly 40 percent. This was accomplished by the realization of production from the increased electrolytic capacity at Corpus Christi, Monsanto, Anaconda and Great Falls; by increased refinery capacity at Depue, and by several retort plants upgrading their production.

As anticipated two years ago, overall requirements have steadily increased. The increase was particularly noticeable in the brass mills, they having assumed the gigantic job of producing cartridge brass and other products for our allies as well as ourselves. Indicative of this was a rise in monthly consumption from 24,000 tons in March 1942 to 40,000 tons in October 1943. Cutbacks now indicate that 33,000 tons monthly will adequately cover requirements for this industry for the balance of the year.

While brass requirements increased on the one hand, zinc for galvanizing decreased. In March 1942 consumption amounted to approximately 25,000 tons

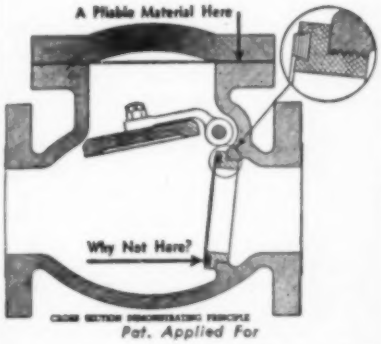
FOR PRECISION Liquid Level Control, K & M pilot-operated REMOTROL allows remote location of valve and yet assures immediate and precise level control in open or closed vessels. Special types for all pressures, temperatures and services. Write for General Catalog 66.

KIELEY & MUELLER, Inc.
MANUFACTURERS OF PRESSURE & LEVEL CONTROLS
North Bergen, New Jersey



WHEATLEY'S

"Syn-Rub-Seal"



Pat. Applied For

SYNTHETIC RUBBER SEAL FULL OPENING, SWING CHECK

VALVE

Equipped with Wheatley Synthetic Seal —a synthetic rubber ring dovetailed and fitted into a removable bronze seat also dovetailed to accept this rubber ring. When the bronze clapper falls against this rubber a perfect seal is formed regardless of what irregularities have deposited on the seat or in the fluid, such as sand, scale and cuttings which under pressure ordinarily would completely cut out a hard-surfaced seat.

Preferred by the United States Engineers on projects handling high octane gasoline.

Sizes 2" to 24"
Pressures
125 lbs. to 2000 lbs.
Series 15-30-40-60
and Ludlow
FBE - SBE - SOE & FOE
Steel-Iron-Bronze

- The rubber ring conforms to all deposits and obstacles and makes it possible for this valve to seal under the worst conditions.
- Seals regardless of viscosity.
- Operates equally well on kerosene or crude.
- Absolutely silent in operation. Ideal for refineries and pumping stations where the slapping of metal check valve clappers is annoying.
- No lapping or grinding of seats necessary.
- Renewable bronze seat ring, into which the rubber ring is inserted, can be replaced by the standard metal to metal seat, if desired.

Write for Bulletin No. CM-1

WHEATLEY
PUMP and VALVE MFR.
Hale Station, Sand Springs Road
TULSA, OKLAHOMA

Use KOLDBOARD Insulation

IT'S WATER-PROOF... FIRE-PROOF

B-H Koldboard makes the ideal low-temperature insulation. It has exceptionally low conductivity and is effective at temperatures from —150° to 300° F. It is made from 100% chemically stable *black*, rockwool fibres, felted and bonded together to form flat, semi-rigid blocks.

Koldboard will not support combustion and it resists the infiltration of moisture, conceded to be the greatest contributory cause of low-temperature insulation failure. It will not disintegrate, decay, or break down structurally under severe service conditions. Send for sample and catalog. *Baldwin-Hill Co., 532 Klagg Ave., Trenton 2, New Jersey. Plants in Trenton, N. J., Kalamazoo, Mich., and Huntington, Ind.*

Baldwin-Hill

BH COMPANY

HEAT & COLD INSULATIONS

Do you need

MULTI-WALL BAGS

in a hurry?

● **If you do—specify TARENTUM. 80 years of experience is evidence of quality and accuracy of manufacturing year after year.**

Tarentum Multi-Wall Bags will be made to your specifications—in any quantity—damp proof or water resistant—printed in any color, on one or both sides.

Send us a sample or give us specifications and quantity required—we will quote by return mail.

Quality and Accuracy

TARENTUM PAPER MILLS

Manufacturers of Paper Since 1865

TARENTUM, PA. **Telephone–1470**

Specify-

REPUBLIC FILTERS FOR *Ultra* FILTRATION

Filtering equipment and media especially designed for the chemical industry to attain the desired degree of porosity and flow rates.

Our laboratory and technicians are at your service.

★

Catalogue on Request

REPUBLIC FILTERS, Inc.

PATERSON, N. J.

480 Lexington Ave., N. Y. C. • 1142 Howard St., San Francisco, Cal.

This figure reached a low of 18,000 tons by the end of that year. Since that time, however, there has been a steady recovery and at present the consumption is running around 23,000 tons monthly. Consumption by other industries has fluctuated comparatively little and today amounts to some 18,000 tons per month. Our export requirement of slab zinc no longer presents a problem. We expect that in 1944 it will amount to only 35 percent of 1943 or 25 percent of 1942.

We have recently examined our second quarter 1944 situation and with estimated supplies exceeding our requirements, we expect a surplus during the period of some 40,000 tons.

For the entire year 1944, we estimate a surplus of supply over requirement to the extent of some 146,000 tons which added to the 156,000 tons at the beginning of the year should find our stocks at approximately 302,000 tons at the beginning of 1945.

Our supply figures represent domestic production at the current rate with no allowance for manpower shortages. Indications lead us to believe that these tonnages may not be attained due to the possible induction of smelter workers into the Armed Services and production may possibly decrease as much as 10 percent. For the same reasons our requirements may fall off and, whether or not these will compensate to the full extent of a drop in production, will have to be determined at a later date.

Our stock position at the beginning of 1944 totaled 155,839 tons. This includes 95,194 tons of high-grade and 60,645 tons of low-grade. The discontinuance of exchange agreements and the redistilling of low grade slab into high grade will make a further adjustment in the relative distribution of our stocks at the end of 1944. Therefore, the 302,279 tons at the end of 1944 will consist of 134,561 tons of high grade and 167,718 tons of low grade.

While no general overall relaxation of use is contemplated at this time, consideration is being given daily to the resubstitution of zinc, especially, when it can be shown that manpower may be conserved. Such items as may be die cast or produced from rolled zinc have contributed considerably to a saving in man and machine hours and available facilities should be used to the fullest extent. Simplification of all limitations have been studied and will be made effective as soon as the opportunity permits.

M. L. Trilsch, WPB, before 26th Annual Meeting, American Zinc Institute, St. Louis, April 17, 1944.

SEDIMENTATION THEORY OF SUBSIEVE, POLYDISPERSE SOLID-LIQUID SYSTEMS

THE DEGREE of dispersion is fundamental to a characterization of subsieve polydisperse solid-liquid systems. Furthermore, gravitational or centrifugal sedimentation methods involving Oden's graphical tangential intercepts are recognized as effective tools for determining particle size distributions, i.e., quantitative measures of dispersity.

In an attempt to improve Oden's tangential intercept technique, a so-called "sedimentation curve equation" was found

to reproduce numerous experimental sedimentation curves with surprising accuracy.

$$p = p_\infty\ (1 - e^{-kt})$$

Where p = wt. percent of the total material sedimented after t minutes; p_∞ = final value of p corresponding to the longest sedimentation time, t_∞; and k = sedimentation curve constant.

The applicability of this equation was established with data obtained in the centrifugation of various types of pigmentary dispersions. Included are comparisons of the newly developed mathematical technique and Oden's graphical method for calculating particle size distributions and corresponding surface areas.

A theoretical analysis of sedimentation resulted in the derivation of an expression for the distribution function in terms of all significant variables.

$$F\ (D) = 2(t^2/D)\ k^2\ p_\infty\ e^{-kt}$$

The equivalent spherical diameter, D, is calculated by Stokes' gravitational or centrifugal sedimentation formula. The preceding equation permits a ready estimation of the absolute error in particle size distribution values.

With the introduction of the "sedimentation curve equation" the experimental data required for graphical intercepts could be markedly reduced. Thus a rapid yet accurate method was developed to determine particle size distributions. It is useful in investigating paint dispersions.

S. W. Martin and G. J. Verbeck, Institute of Gas Technology, before Division of Colloid Chemistry, American Chemical Society, Cleveland, Ohio, April 6, 1944.

OUR CIVIC DUTIES

Our present era is characterized by something new in the life of man, and that is the impact of science and of applied science or technology on our lives. Our ultimate goal is not science, just for science's sake; our goal is a higher degree of culture and civilization. We should realize that science is not the measure of civilization—science and technology are merely tools, not ends in themselves.

Science must be blended with a recognition of moral principles and these principles must be properly applied. Therefore, if scientists and technologists are to play a greater part in the world of tomorrow, they must accept wider responsibilities which will take them out of their laboratories and plants and into the life of the nation.

Within the past 50 years the chemist's outlook has changed completely. Only 50 years ago, absurd as it may now seem, we thought we understood the field of chemistry and could define its limits of usefulness. We had a smug, a comfortable feeling that all the important elements were known and doomed to remain unchanged as we had found them to be. Now all that has been swept aside and we are disturbed, for we recognize how little we know.

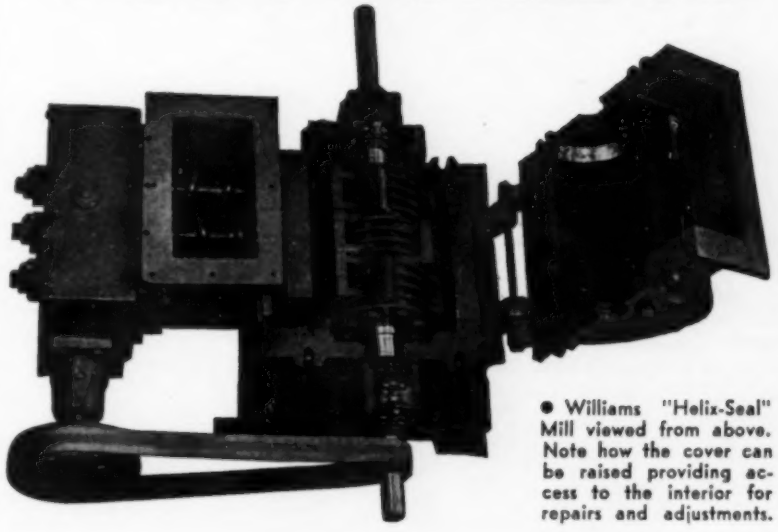
There have been other changes, too. Thirty years ago there was a belief in government circles that the business of dealing with chemicals was something for the British and Germans, but not for Americans. Let the dreamers and the dilettantes of Europe play with pretty things in glass dishes, we were workers of wood and iron and stone, those more fundamental things.

Williams

OLDEST AND LARGEST BUILDERS OF HAMMERMILLS IN THE WORLD

PATENT CRUSHERS GRINDERS SHREDDERS

"HELIX-SEAL"
PULVERIZERS



• Williams "Helix-Seal" Mill viewed from above. Note how the cover can be raised providing access to the interior for repairs and adjustments.

• • GRIND WET OR STICKY MATERIALS
• • FINE GRIND—100 TO 325 MESH
• • NO OUTSIDE SEPARATION NECESSARY
• • INEXPENSIVE TO INSTALL

• The Helix-Seal Mill grinds extremely fine without the aid of outside separation. This is largely due to the long grinding surface, adjustable grinding parts and high speed of the hammers. Due to the screw feeder which acts both as a feeder and seal, sealing the intake opening against the in-rush of air, no air is sucked into the machine and consequently there is no resulting dust carrying draft expelled from the discharge. Built in nine standard sizes, capacities 200 pounds per hour and up.

THE WILLIAMS PATENT CRUSHER & PULVERIZER CO.
2706 North Ninth St. St. Louis, Mo.

Sales Agencies Include

CHICAGO
37 W. Van Buren St.

NEW YORK
15 Park Row

OAKLAND, CALIF.
1629 Telegraph Ave.

IS THIS THE RIGHT PUMP FOR THE PROCESS ?

—the right size, type, material, drive? . . . If not, we're sure to have the *right* one. We've been making pumps for over a quarter of a century, and can supply pumps for every process need. Available in stainless steels, acid-resistant bronzes, nickel, lead or any required alloy; in horizontal or vertical types and in any combination of single or double suction and single or multi-stage; in direct connected, belted, chain or geared drives. Of rugged construction—guaranteed to meet the conditions for which they are sold. Call on us next time you need pumps for process work.

THE *Frederick* IRON & STEEL CO.
Frederick, Maryland

WELDING · ASSEMBLY · PUNCHING · CUTTING
LIGHT SHEET METAL WORK
FILTER CLOTH · WIRE CLOTH
SOLDERING · BRAZING · ROLLING · FORMING

IF IT'S *QUALITY* THAT YOU WANT

● If you want trouble-free, long-lasting Wire and Filter Cloth assemblies or sheet metal fabrication, submit your problem to us. Most likely we can solve it as we have solved hundreds of seemingly unsolvable problems for our clients during the last 32 years.

Materials of the highest quality combined with skilled workmanship have given Multi-Metal products their proud position of leadership and assures you of finished products of the best quality obtainable.

MULTI-METAL
WIRE CLOTH COMPANY
INCORPORATED
1360 GARRISON AVE., BRONX 59, N. Y.

WIRE CLOTH
FILTER CLOTH
ALL MESHES
ALL METALS

Applied chemistry is indefinable because it has no definite limits—it overflows its boundaries and invades territories where it was not supposed to be. For example, rubber has been for a century a natural product obtained from trees, but now almost overnight we have converted the rubber industry into a branch of the chemical industry, with an output valued at over $400,000,000

But the industrial invasion of inanimate chemicals is not the entire story, great as this may be, for outside of the purely technological developments, the chemist as an individual has extended his sphere of activities. It started in this country about 20 years ago when he, having supplied the needs of the buyers who sought his products, began to look for new uses for his products and to seek buyers for such new uses. This release of the cloistered chemist of early days resulted in direct contacts between him and men in other industries. The chemist stepped out of the laboratory to find new customers—new customers for his brain-children—and from there to the chemist as a salesman and emissary of his science was but a short step. Today in the United States there are thousands of chemists now active in promoting new uses for the products of the chemical laboratory. The chemist is in touch with the world, with men, with other industries, and it is time that we consider whether we, as chemists, are prepared to shoulder the responsibilities corresponding to the important role we will play in the future.

There is some confusion in the minds of many as to just what role the scientist should play in our world. But what should concern us now is the marked evolution in the ideas of the world's citizens in regard to the relation of science and of scientists to the rest of the world.

The solution to this should be in the minds of all of us, for science is now rapidly becoming more and more important to civilization. As the chemist steps out of his laboratory, he must accept the responsibility that is consistent with his new status. It is absurd to claim that the chemist's first duty is to science. His first duty is to his fellow men, because he is one of a team, like the butcher, the baker, the candlestickmaker. It seems imperative, therefore, that we scientists must also be prepared to carry our ideas forward into action, like the merchants and businessmen.

The progress of the chemist cannot be measured by his technical achievements alone. His real achievement can be evaluated only by the service he renders to his fellow men, and for this purpose his technical skill must be combined with a consciousness of civic duties.

We should assume those civic responsibilities for which we are, through our training, best suited. We should take a very definite interest in the use and control of science, and this will lead to an interest in law and government.

Our first duty should be to see that these, our fundamental ideas, are broadcast and generally accepted by the members of our profession. Our scientific societies should recognize these objectives and through discussion at our meetings, we should disseminate these ideas and let

them mature, so that in time the collective judgment of our scientists will help mold national policies.

The responsibility of the chemist with respect to our patent system is greater than ever before. I approve of the American patent system, but, at the same time, recognize that it can be improved. We now have the report of the National Patent Planning Commission, and what are we, as chemists, doing about the proposed changes in our patent system?

And what about the manufacturing activities of our government? Are we competent to lay down rules which should govern such activities? Should our government in peacetime manufacture nitrates, ammonia, styrene, butadiene, carbide, synthetic rubber, phosphorus, fertilizers? Can our government successfully compete with industry? Facts should be obtained without prejudice or partisanship.

The nation has recognized during this war the importance of science and technology to our safety and progress, and we will be called upon to perform a heavy task in the postwar years. This calls for leadership, and leadership by members of the "Fifth Estate." We can no longer claim allegiance to science first. We have a much greater responsibility to serve our fellow men first through the use of science. It is now up to us, with the help of our scientific organizations, to think and live in a broader field of usefulness to society, and when some of our members are asked to assume greater responsibilities, we will discover a ready and willing cooperation from industry and universities. The scientist is not out of this world, he is in it, and should add his learning and voice to the solution of national problems.

G. F. DuBois, Monsanto Chemical Co., at Perkin Medal Presentation, New York, Jan. 7, 1944.

PATENT WORK AS A FIELD FOR CHEMISTS

THE OPPORTUNITIES for well-trained chemists in patent work are being largely overlooked, in spite of a published survey of A. C. S. members showing salary rates in this work to be quite attractive. Lack of information is responsible.

Chemical patent work requires a knowledge of (1) chemistry and (2) patent law and procedure. A survey of the leading law schools of the country made in 1941 showed that practically none of their LL.B. graduates had had full undergraduate training in chemistry. The rare law school courses in patent law are inadequate preparation for practical patent work or the Patent Office registration examination. A law degree or bar membership is not prerequisite to such registration.

A shortage of patent chemists has existed for several years. A number of corporate patent departments train chemists to meet this shortage. Experience has shown that chemists can be readily trained in this work. Legal training is an advantage but is at least counterbalanced in the bulk of the work by stronger chemical training.

Patent chemistry is inherently interesting to research-minded chemists. Its two major phases of the protection of research by obtaining patents and the study of

Latest data on Non-sparking Safety Tools

— in Ampco's new 28-page catalog . . .

AMPCO
REG. U.S. PAT. OFF.
non-sparking
Safety Tools

460 standard types and styles are illustrated and described. Tools for a wide variety of purposes — for use wherever a spark may ignite explosive fumes, gases or dust. (Special types fabricated to your specifications when necessary.) Approved by Factory Mutual Laboratories, other insurance authorities; frequently required to earn lowest rates. • Protect lives and property — equip with Ampco Safety Tools. Write on your business letterhead for your copy of this book. *Ampco Metal, Inc., Dept. CM-5, Milwaukee 4, Wis.*

S-5

HERE are THE ANSWERS

. . . to your questions about CENTRIFUGAL SEPARATION

Whatever your process, there's a Fletcher Centrifugal that will do it faster, more economically and with absolute safety. Fletcher design and construction are keyed to the speed demanded by today's all-out production schedules. Operating advantages are a direct result of exclusive Fletcher engineered improvements: the Sight Feed Lubrication, the "Centroid" Speed Control, the Interlock Switch that automatically shuts off current when brake is applied, the Wood Buffer Ring that protects the basket even with loads badly out of balance, the rugged Flexible Coupling Drive—these and many other special features are all *fully* described in the Fletcher catalog. Available basket types and sizes are given, and there's a handy, detachable Centrifugal Force Diagram that you'll find most helpful.

Before you buy, you naturally want to thoroughly investigate every possibility . . . We want *you* to have a copy of the Fletcher catalog. Use the coupon provided here—and remember, your further inquiries are invited.

Fletcher Works
Glenwood Ave. & 2nd St.
Phila. 40, Pa.

Send me a copy of your catalog
FLETCHER CENTRIFUGALS

Name_____

Address_____

City_____ State_____

FLETCHER CENTRIFUGALS

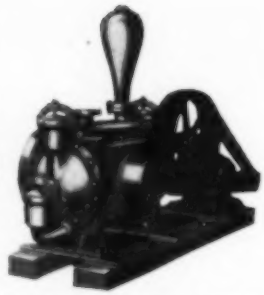
FOR HEAVY DUTY

ON SLURRIES · SLUDGES · THICK CORROSIVE or ABRASIVE FLUIDS

Constant Pumping

Lowest Maintenance

No Contact Between Fluid and Working Parts

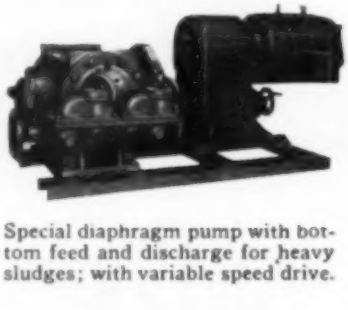


Standard diaphragm pump with liquid ends of any metal, rubber or plastic covering; built for any drive.

Complete separation of fluid and mechanical parts; positive suction and discharge at pressures to 100 p.s.i; absence of packings and leakage; corrosion resistant construction—all these features are combined in Shriver Duplex Pumps to assure steady operation where other types wear out or break down all-too-frequently in tough metallurgical plant service.

Let the judgment of hundreds of mining, metal refining and chemical plant users guide you in selecting the pump that can really "take it" on those tough materials.

Write for Bulletin 112.



Special diaphragm pump with bottom feed and discharge for heavy sludges; with variable speed drive.

T. SHRIVER & COMPANY, Inc.
802 Hamilton St. Harrison, N. J.

SHRIVER DUPLEX DIAPHRAGM PUMPS

WANTED!

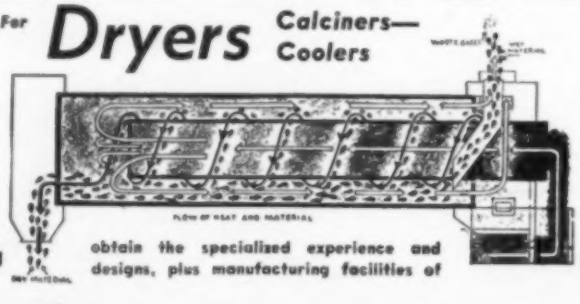
Wet Process Factory

on Eastern Seaboard or will supply raw materials for conversion to finish products.

WILLIAM D. NEUBERG COMPANY
Chemicals

GRAYBAR BUILDING • 420 LEXINGTON AVE • NEW YORK 17, N. Y. • TELEPHONE LEXINGTON 2-3324

For **Dryers** Calciners— Coolers



obtain the specialized experience and designs, plus manufacturing facilities of

THE L.R. CHRISTIE CO. 17 E. 42nd St., New York 17, N. Y.

Send us your problems—we would enjoy solving them.

patents in relation to new chemical processes both involve handling new ideas and the analysis of chemical data. A patent chemist will analyze many times the amount of research data handled by the average research chemist.

C. B. Hollabaugh, Hercules Powder Co., before Division of Chemical Education, American Chemical Society, Cleveland, Ohio, April 3, 1944.

SODIUM PEROXIDE BLEACHING OF MECHANICAL PULPS

In connection with postwar planning in the pulp and paper industry, a considerable interest has developed in the sodium peroxide process for bleaching mechanical pulps. This process is still in the development stage and the outlook on the availability of sodium peroxide for pulp bleaching is not favorable for the duration.

Development work on the sodium peroxide bleaching of mechanical pulps has shown that substantial increases in pulp brightness are obtainable with practically no weight loss at a cost well within economic limits. The bleached pulp retains most of the desirable properties of unbleached groundwood and some new valuable pulp characteristics are developed in the bleaching treatment. Paper mill operations have shown that the bleached pulp can be used to advantage in the production of a wide range of papers.

The process includes three principal operations: (1) rapid and thorough mixing of the sodium peroxide bleaching solution with the pulp in controlled proportions, (2) storing the treated pulp long enough to permit the bleaching to go to completion, and (3) mixing the bleached pulp with a neutralizing and reducing agent, preferably sulphite cooking acid.

The chemicals used in the sodium peroxide bleaching of mechanical pulps include sodium peroxide, sodium silicate and sulphuric acid. An investigation is now in progress with the objective of determining the conditions under which the bleaching treatment should be applied for best results.

Brightness increases obtained in the bleaching treatment increase with the percentage of sodium peroxide used in the treatment. With 2 percent sodium peroxide the pulp brightness increases from a starting brightness of 58 to 61 to a bleached brightness of 68 to 71, an average increase of 10 points.

In the range of 3 to 7 percent pulp consistency, the brightness increases obtained in the bleaching treatment shows a progressive increase with the pulp consistency.

The bleaching time varies with the pulp consistency, the bleaching temperature, and the percentage of sodium peroxide used in the bleaching treatment; at a consistency of 5 percent and at a temperature of 90 deg. F. a time of 5 to 6 hr. is required for bleaching with 2 percent sodium peroxide.

The amount of total alkali present during the bleaching treatment has a very marked effect on the bleaching results. Proper proportioning of the chemicals in the preparation of the bleaching solution and also proper proportioning of the pulp with the bleaching solution are required. When bleaching with 2 percent sodium peroxide at a consistency of 5 percent and

a temperature of 90 deg. F. the best bleaching results were obtained when the chemicals were used in the following amounts: 2 percent sodium peroxide, 4 to 5 percent sodium silicate, and 1.7 percent sulphuric acid on the weight of the pulp (moisture-free basis).

Some of the heavy metals such as copper, iron and manganese have an adverse effect on the stability of peroxide solutions. The reaction is catalytic and is most apparent in alkaline peroxide solutions. The activity of these metal catalysts varies also with the form or chemical composition in which they exist in the peroxide solution.

In the bleaching of mechanical pulps with sodium peroxide, small amounts of iron, copper and manganese are usually present in the wood and in the mill waters. These metals may be present in an active form or they may be chemically combined with other constituents of the wood or mill waters in an inactive form. The traces of catalytic metals in the wood are comparatively inactive, probably because they are tied up as undissociated salts of complex organic acids. However, the metals present in the mill waters are likely to be more active catalytically, and therefore, may be expected to have an adverse effect on the bleaching results unless steps are taken to deactivate them.

Magnesium salts are known to have a profound stabilizing effect on alkaline peroxide solutions, especially in the presence of sodium silicate. This stabilizing action, which is based on the deactivation of the catalytic metals by the magnesium salts, is being applied to advantage in many commercial applications of alkaline peroxides.

Considerable information has been developed on the effectiveness of magnesium sulphate for controlling the catalytic activity of iron, copper and manganese salts in the groundwood bleaching process. Losses of active oxygen from the sodium peroxide bleaching solution are reduced to a point where they are negligible by the addition of a small amount of magnesium sulphate. When appreciable amounts of heavy metals are present in the pulp slurry, the bleaching results are improved by adding a small amount of magnesium sulphate to the pulp before applying the bleaching treatment.

J. S. Reichert, D. J. Campbell, R. A. Secord and R. T. Mills before 29th TAPPI Annual Meeting, New York, Feb. 1944.

PYROLYSIS OF CYCLOHEXANE

NONCATALYTIC thermal decomposition of cyclohexane has been investigated over a temperature range of 1,300 to 1,600 deg. F. and contact times of 0.1 to 1.0 sec. The use of steam as a diluent was studied. The work was carried out in glass equipment based on a quartz pyrolysis tube. Cyclohexane feed rates were varied from 1 to 55 ml. per min. The pyrolysis products consisted of hydrogen, methane, ethane, ethylene, propylene, isobutylene, butene-1 and 2, butadiene, and an undetermined liquid residue.

The results indicate that increased temperature and lengthened contact time have essentially the same effect upon the nature of the gaseous product; extremes of either of these tend to favor the exclusive decom-

AMERICAN

ROLLING RING CRUSHERS

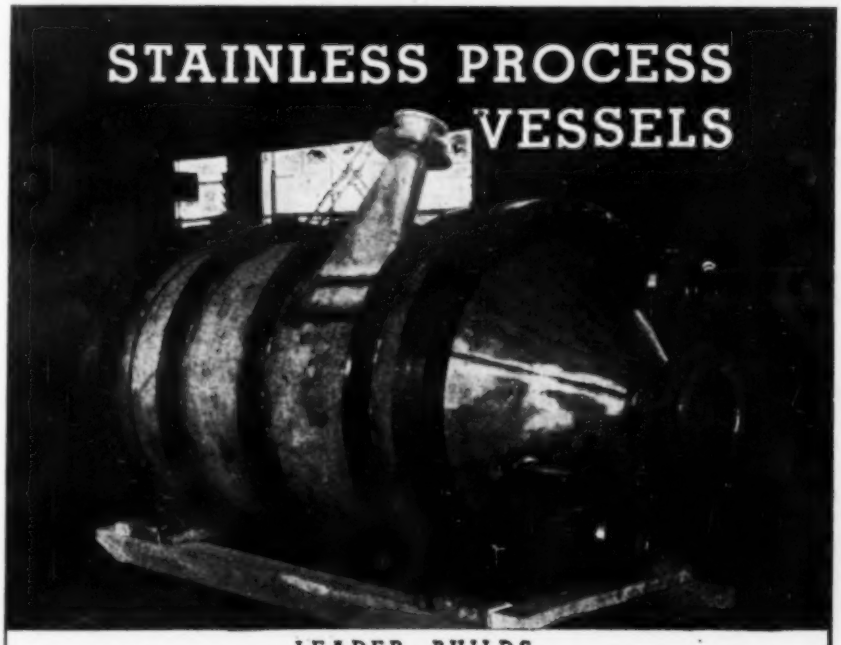
Big economies in grinding all kinds of Chemical Raw Materials

More tonnage per hour—more uniform product—no slivers or chips—minimum of fines . . . that's why leading process industry plants rely on AMERICAN Rolling Ring Crushers for grinding, reducing, and pulverizing. Wide operating range, very flexible, all parts tested for quality, wear, and endurance. Avail yourself of AMERICAN engineering service — tell us what you want to grind and we will recommend the proper method.

Patented reversible manganese steel SHREDDER RINGS are the secret of AMERICAN Rolling Ring Crushers' success. Rings have 20 cutting edges or teeth—designed to maintain outward position by centrifugal force at specific speeds. In contact with solid metal, rings are momentarily deflected from usual course because they are free to swing back out of position. No shear pins or other safety devices that require attention.

AMERICAN PULVERIZER CO. 1119 MACKLIND AVE. ST. LOUIS, 10, MO.

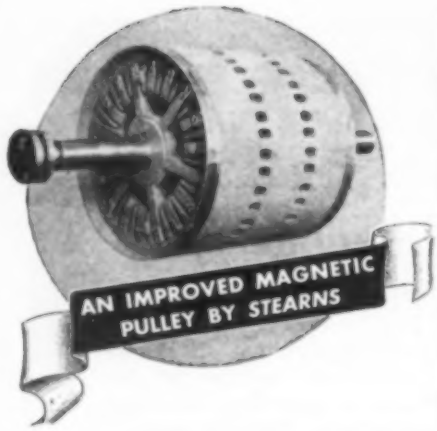
STAINLESS PROCESS VESSELS



LEADER BUILDS

TANKS — KETTLES — FRACTIONATING COLUMNS
HEAT EXCHANGERS and SPECIAL EQUIPMENT
OF
STEEL—STAINLESS STEEL—NICKEL—MONEL
INCONEL—COPPER—EVERDUR—HERCULOY
HASTELLOY — ALUMINUM and CLAD STEELS

LEADER IRON WORKS, INC.
2200 N. JASPER DECATUR, ILLINOIS



STEARNS PIONEERED THE COOL MAGNETIC PULLEY

Today's accepted principle of forced ventilation in magnetic pulleys has always been a feature of STEARNS design and construction.

NOW—still greater cooling is provided by STEARNS better engineering through increased heat radiation area in a ribbed design which allows for deeper coils with more ampere turns and consequent greater magnetic pull.

A rugged magnetic pulley with power, economy and trouble-free operation at maximum peak loads. In sizes to fit your conveying system or in complete separator units. Bulletin 302.

STEARNS Suspended magnets, circular, rectangular and other shapes and all sizes. Our Bulletin 25-B describes fully.

We will be glad to test your material, 25 to 50 lbs. prepaid for analysis and recommendation.

STEARNS MAGNETIC MANUFACTURING CO.

624 S. 28th St. Milwaukee, Wis.

position to hydrogen, methane, and ethylene. The maximum yield of butadiene is obtained at conditions which give a depth of cracking equal to 35 to 45 lb. of C_3 and lighter per 100 lb. of cyclohexane charged. The maximum amount of butadiene obtained is 12 percent per pass using steam as a diluent and 9 percent per pass in the absence of a diluent. Maximum ultimate yields in either case are 25 to 35 percent. Short contact time tends to favor higher concentration of the butadiene in the C_4 fraction.

G. L. Sumner, Jr. and Lloyd Berg, Gulf Research & Development Co., before Division of Industrial & Engineering Chemistry, American Chemical Society, Cleveland, April 3, 1944.

TECHNICAL SERVICE

TECHNICAL service includes all phases of the application of the chemical products prior to the consumer. Technical service has as many different interpretations as there are companies which employ this means of introducing and assisting the application and consumption of their products in the hands of their customers. The duties of technical service are not outlined in detail as are the duties of production and the duties of the sales departments of chemical producing companies. Broadly speaking, technical service is maintained by the chemical producing companies to apply the properties of their products, design equipment, and processes to consume these chemical products, investigate processes in the producer's laboratories to evaluate various methods of consuming newer products produced at the research laboratories, and contact customers with or without the assistance of the sales personnel on all phases of work involving the use of such chemical products.

The technical service reports to the sales department as a general policy in chemical producing companies. Some companies maintain a technical service laboratory for their customers in which the technical service men carry out the field problems.

On the other hand, some companies do not provide laboratory facilities for their technical service personnel, but prefer to have field problems submitted to their regular laboratory organizations and reports issued. There are advantages and disadvantages to some of these methods of operating technical service departments, but the general idea of personal operation of a technical man in the customer's laboratory should be based on the experience of the laboratory work at the chemical producing company.

The size of the field of technical service is increasing with the number of chemical companies in the country. One large chemical manufacturer has a technical service department of over 100 men to spend the major part of the time in the company's laboratory working out new fields of application of the products produced by the research department. Another chemical company spends the major part of the technical service department's personnel in the field working on customer's problems. The wide latitude of the technical service field is thus seen by these two extremes.

Recently representatives of about 50 chemical producing companies exchanged ideas and discussed in general typical problems of mutual interest in order to develop one of the most important and least mature phases of the chemical industry. Both heavy and fine chemical manufacturing companies maintain some type of technical service for their customers, which in various degrees is dependent upon the available category of the research department of the production department.

The personnel of technical service in chemical producing companies consists of both graduate and postgraduate chemists and chemical engineers, either trained by the chemical producing companies themselves or obtained from specialized industries consuming the products of the chemical manufacturer.

Competitive conditions in the industry favor such trained technical service personnel in the chemical producing industries. Another trend is increasing for chemists as purchasing agents in order to provide ample and accurate contact with technical service men and sales staff of supplying companies.

The personality of the technical service personnel is an essential requirement to contact the technical staff and technical representatives of consuming companies. The existence of the technical service department is justified only on the basis of profit returns to the company, as they do not take orders directly for chemicals.

C. W. Ripple, Diamond Alkali Co., before Division of Chemical Education, American Chemical Society, Cleveland, Ohio, April 3, 1944.

SHRIVER FILTER PRESSES

FOR NEW PROCESSES BETTER TECHNIQUES

in

CAKE RECOVERY
WASHING SOLIDS
DRYING CAKE
EXTRACTING
DISSOLVING
MELTING
THICKENING
CLARIFYING
DECOLORIZING
GERM-PROOFING
DEODORIZING
WINTERIZING
HOMOGENIZING

At Any Temperature or Pressure
For Any Volume of Production
Under Any Operating Conditions

Write for Catalog

T. SHRIVER & COMPANY, Inc.
802 Hamilton St. Harrison, N. J.

INVASION *and the* FINAL CHALLENGE

The idea that our national security some day would depend upon the successful invasion of continental Europe by our armed forces was inconceivable to the average American but a few short years ago. Yet, today our whole strength is assembled to that very action and for assuring a sound and permanent peace.

America became great without aggression . . . without tyranny. Our greatness has been achieved without destroying others . . . ours is a history of unprecedented industrial progress, of development of our own resources and reliance on our own efforts.

Aggression is foreign to American philosophy. Yet, today we find ourselves faced with the choice of destroying or being destroyed. Today we are confronted by the hard fact that the kind of peace which we all so fervently desire can be achieved only by crushing autocracy and by removing the causes of aggression.

We are now engaged in the accomplishment of the first objective. Since Pearl Harbor a complacent, peace-loving America—the largest of the "soft" and "decadent" democracies—has grown strong and tough. Out of the inherent virility of a free people we have moulded the mightiest force for invasion and attack that the world has ever seen.

We have reached our peak rates of war production. We are producing as much war equipment as all the rest of the world combined.

History will record our industrial mobilization as a phenomenal achievement.

The battle of production has been won!

The full might of our armed forces and those of our allies unleashed against the Axis war machine will bring eventual victory. Two and a half years of intensive preparation, backed by 168 years of growth as a free nation, has given us superiority over twenty years of painstaking preparation by the totalitarian and militaristic countries with their enslaved peoples.

Every American has contributed toward this powerful offensive. Our manufacturers and business leaders have exerted their fullest efforts. Our industries have mobilized their tremendous resources—tapped to the fullest degree their inventive and productive genius. The men and women in the factories, on the farms, and in the mills and mines have played a magnificent

part in the tremendous production program. Citizens all are making their contribution to the armed victory that lies ahead

We have demonstrated that a free people under a free enterprise economy can unite in a common purpose.

* * *

When the war is won, we shall be faced by our second objective . . . removing the causes of aggression. This is a social challenge. A challenge to those who would sacrifice our democratic way of life for personal gains or foreign ideologies.

The best insurance for the continuance of our democracy is a successful democracy. That means a dynamic and not a static democracy. All of us who want to preserve the ideals that have made America . . . and that includes all but a handful of extremists . . . must determine to find the policies and programs which will permit us to make the most of the abundance nature has provided for us.

To achieve this end we must recognize the fact that we are but a wheel in the machinery of world economy. A wheel that must drive or be driven. A wheel that must mesh smoothly with the many other wheels or be stripped of its cogs.

We are the only nation on earth free enough and strong enough to shape the mould of its own destiny. We can be hampered by nothing but our own confusion.

* * *

The mind and the heart of all America today brood over the shores of Britain and watch over the narrow waters that wash the beaches of the Continent. And the prayers of all America go with each of those who embark upon that epic passage.

Those of us at home who are producing the fighting tools and who are so earnestly concerned with the problems that will face a postwar America, should see now, even if we may never have seen it before, that all our plans will be worth just exactly what the men and women who make that passage are prepared, competent, and inspired by their leadership to make them worth.

For those men and women are America.

They have gone out from rich homes and poor homes alike, from farms and factories, from schools and churches, from mines and ranches, from offices and studios, to take their places in the battle line. They are a cross-section of the America that is to be.

Whoever may draw the plans for that America, it is those men and women who will make the plans good. Invasion is their first step toward that end. May their work be speedily done, and may our plans be worthy of that work.

James H. McGraw, Jr.

President, McGraw-Hill Publishing Company, Inc.

FOREIGN LITERATURE ABSTRACTS

UTILIZATION OF COFFEE

SINCE Brazil was reported to possess 2,303,400,000 coffee trees in 1940-42, as compared with 2,541,400,000 for all other producing areas combined, this country is deeply interested in furthering any process which provides additional industrial outlets for their product. Although every effort has been made to complete the Cafelite plastic plant, this unit had not yet reached the large scale production stage by 1943. All developmental work in connection with this new project has been supervised by Herbert S. Polin, the inventor of the process, who feels that the plastic still does not have sufficiently satisfactory physical and mechanical properties. There is no question, however, that the coffee-derived plastic is promising and plans are being made for producing it on an industrial scale in the near future.

The Polin process will provide an outlet for considerable amounts of coffee which is unfit for consumption as a beverage due to lengthy storage or inferior quality. In 1942, over 138 million kg. of such coffee had to be incinerated.

Digest from "Brazil Coffee in 1942" by Jayme Fernandes Guedes, Departamento Nacional do Cafe, Rio de Janeiro, Brazil, 1943. (Published in Brazil.)

POLAROGRAPHIC APPARATUS

WITH the recent development of polarographic techniques, analytical methods are now available in which the actual time required for completion is but a few minutes. Nevertheless, the process for removal of oxygen from solutions to be polarographed still often consumes a considerable amount of time, particularly at low concentrations and at high galvanometer sensitivities. In these cases even a minute proportion of oxygen gas will cause considerable trouble.

The apparatus shown permits the complete removal of oxygen from a volume of 2-3 ml. in approximately half a minute. The apparatus is in the form of an atomizer. The stream of purified nitrogen

Brazilian Coffee Exports

Year	Quantity, 60-kg. Bags — Total	Quantity, 60-kg. Bags — Index	Value, Cruzeiros — Total	Value, Cruzeiros — Index
1933	15,459,309	100	2,052,858,224	100
1934	14,146,879	92	2,114,511,730	130
1935	15,328,791	99	2,156,599,349	105
1936	14,185,506	92	2,231,472,515	109
1937	12,113,088	78	2,128,615,805	104
1938	17,203,422	111	2,296,010,010	112
1939	16,645,093	108	2,254,115,311	110
1940	12,053,499	78	1,589,956,317	77
1941	11,054,566	72	2,017,544,619	98
1942	7,279,658	47	1,965,737,736	96

SAVE WITH AN ENGINEERED **READING** CRANE AT STANDARD PRICES

If you have an unusual or particularly difficult materials handling problem, you can get a "custom built" Reading crane for the job at standard prices. This is made possible by the simple unit design which gives a high degree of flexibility to meet special conditions with standard equipment. Hoisting speed, trolley speed, length of span, length of lift can all be readily adjusted to meet your special needs... all without any sacrifice of the accessibility of operating parts and ease of maintenance.

For full information on how Reading cranes can be engineered to fit your needs write for the bulletin, "The Why and How of Faster Production."

READING CHAIN HOISTS·ELECTRIC HOISTS OVERHEAD TRAVELING CRANES

READING CHAIN & BLOCK CORP. 2105 ADAMS ST., READING, PA.

TONNAGE SCREENING WITHOUT SCREENS

on low priced products

WITH AIR TABLES . . .

THERE are many bulk articles that cannot be economically fine-screened because of the cost of replacing screen cloth. Sutton, Steele & Steele Air Tables handle large quantities per hour with no screen cloth—hence, no screen cloth replacements.

A striking example

FOR instance—granite fines running 22% minus 100 mesh were made by Air Tabling into two divisions, of which one (or 72% of the original) ran 95% plus 100 mesh while the other (or 28% of the original) ran 87% minus 100 mesh, at the rate of 4½ tons per hour, at a cost of a few cents per ton.

CONSULT US about the use of Air Tables either as Concentrators of different materials, or as Graders of homogeneous materials, or as Controllers of bulk density. We will gladly run samples.

SUTTON, STEELE & STEELE, INC.
DALLAS, TEXAS
SALES OFFICES
SEPARATIONS ENGINEERING CORPORATION
110 EAST 42nd STREET, NEW YORK, N. Y.
CLARK BUILDING, PITTSBURGH, PENNSYLVANIA
ENGINEERING BUILDING, CHICAGO, ILLINOIS
FLOUR EXCHANGE BUILDING
MINNEAPOLIS, MINNESOTA
41-43 DRUMM STREET
SAN FRANCISCO, CALIFORNIA

THE S&S PROCESS FOR BETTER PRODUCTS-FASTER

Next to Correct Hopper Design . . .

SPLIT-DUCT MANIFOLD

No. 5 Reason for

Buell's High Efficiency, Low Maintenance, Long Life

• THE SPLIT-DUCT manifold as used on Buell multiple-cyclone collectors is designed to assure *uniform* distribution of both gas and dust to the cyclones. This design is most important to the final efficiency of the collector; for uneven dust distribution can cause local recirculation of gas with the consequent impairment of efficiency. Uneven distribution of dust results in greater erosion rates in the cyclone collectors receiving the higher concentrations. ☆ With Buell's split-duct manifolding, the maximum efficiency is attained by reason of this even gas distribution. The outlet can be installed to discharge the cleaned gases from any side or end—a flexibility of arrangement that is impossible with unit-chamber manifolding. ☆ These advantages are indicative of the careful design and workmanship throughout every Buell Dust Collector, and their superior performance is attested by more than 500 installations in United States industries alone. ☆ Every Buell installation is designed especially for its own individual job and purpose.

Engineers will find substantiation of these claims in Buell's factual, 28-page book—"The van Tongeren System of Industrial Dust Recovery." Ask for Bulletin G-842.

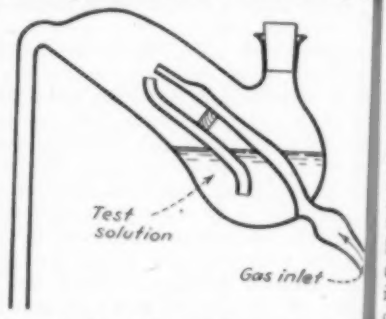
BUELL ENGINEERING COMPANY, INC.
18 Cedar Street, New York 5, N. Y.
Sales Representatives in Principal Cities

buell
DUST RECOVERY SYSTEMS

BUELL FEATURES	RESULT IN	PRODUCE
SHAVE-OFF	HIGH COLLECTION EFFICIENCY	GREATER RECOVERY
LARGE DIAMETERS	LESS FAN BLADE WEAR	LOW MAINTENANCE
EXTRA-THICK METAL	LOW DRAFT LOSS	LOW OPERATING COST
LARGE OUTLETS	LOW POWER CONSUMPTION	LONG LIFE
INNER WELDS GROUND SMOOTH	HIGH TEMPERATURE RESISTANCE	NO CLOGGING
CORRECTLY DESIGNED HOPPERS	UNLIMITED CAPACITY	
SPLIT-DUCT MANIFOLDS	NO MOVING PARTS	
	FREE DUST FLOW	

DESIGNED TO DO A JOB, NOT JUST TO MEET A "SPEC"

or hydrogen comes into such intimate contact with the mist particles that instantaneous saturation with the gas and removal of oxygen results. The mist is projected against the sides of the vessel, co



denses in the delivery tube, and runs in the electrolysis cell. No detectable crease in concentration occurs throu evaporation of the solvent.

Digest from "Polarographic Apparat by E. Weinig, *Chem. Fab.*, October 1 361. (Published in Germany.)

DIESEL FUELS

IN THE normal operation of a Diesel engine, fuel is sprayed in and ignited by heat of compression without any ot source of ignition. However, delay ignition alone is not a sufficient basis evaluating the quality of a Diesel fuel, two different fuels may show the s ignition delay without giving the s motive power to the engine. In exp ments on measuring the knock in the engine conducted in Germany, the elec acoustic method was also used with D engines in order to evaluate each fuel w respect to its behavior in burning.

Ignition delay, pressure rise, maxim pressure and magnitude of noise were determined at the same time that differ fuels were investigated. It was found fuels with the same ignition delay ca the same time show a lower rate of c bustion. It was established in these exp ments that the highest possible comp sion ratio does not always result in greatest power factor. This is especi noticeable with the inferior fuels, du the poorer mechanical efficiency connec with the high compression ratio.

Digest from "The Motor Valuation Diesel Fuels" by A. W. Schmidt and A Schmid, *Motor-technische Zeitschrift* 189-193, 1943. (Published in Germany

ACETYLENE POLYMERIZATION

ACETYLENE does not polymerize dire to benzene but to a compound having general formula C_4H_4, called "polygen cause it readily polymerizes to tarry stances when heated.

When acetylene was heated to 400 deg. C. at pressures of 760 mm. t stages were observed in the process. D ing the "induction period," the pres remained practically constant, after w the reaction rate increased rapidly. Du the second period the pressure-time r tionship corresponded closely to the kin equation for the dimerization reaction the second order. During these first stages the surface of the reaction vessel mained free of deposits of both carbon of high polymers. Kinetics curves o

cided though the reaction vessels were of different kinds of glass and had different surface-volume ratios. This probably indicates that the process was homogeneous.

After about 50 percent conversion, the third stage of the process began when the reaction became heterogeneous and high polymers were deposited on the walls, carbonizing in the hotter regions. Pressure dropped to less than half as a considerable amount of polymer deposited. This was followed by a more gradual pressure loss, probably because of secondary reactions. As little as one percent nitric oxide had the effect of prolonging the induction. Kinetics beyond the first period were unchanged. Nitric oxide was consumed during the induction period, but there was no change in volume. When a large amount of nitric oxide was added to acetylene, the reaction rate was proportional to the square of the concentration of acetylene.

Digest from "Thermal Reactions of Acetylene. I. Kinetics and Mechanism of Thermal Polymerization of Acetylene and its Reaction with Nitric Oxide" by D. A. Frank-Kamenetzky, *Acta Physicochimica* 18, No. 2-3, 148-156, 1943. (Published in Russia.)

CARBON MONOXIDE SYNTHESES

CARBON monoxide gas for synthetic processes which are conducted at low temperatures must be thoroughly purified, not only of hydrogen sulphide but of organic sulphur compounds as well. The sulphur content can be reduced to less than 0.1 g. per 100 cu.m. of gas. This extends the life of the catalyst and resultant gasoline is free of sulphur and therefore highly susceptible to lead treatment.

Fischer and Tropsch found that with cobalt they could obtain synthesis at 190 deg. It is easy to produce pure methane free of homologs, but it has not yet been possible to produce any single homolog. The result is always a series of homologs, though the volume of the homologs can be guided toward either the low-boiling or the high-melting side. Methanol can be produced at pressures over 100 atmospheres with zinc oxide catalyst.

The Kogasin normal pressure synthesis yields aliphatic hydrocarbons with straight chains predominating. Nickel, cobalt and iron act as the catalyst if they are present in highly active form. The hydrocarbons formed yield Gasol, Diesel fuel and high-melting paraffins.

Catalysts may act as hydrides, as carbides or as carbonyls but in any case, they form labile intermediate compounds. Nickel, cobalt and iron act as the carbide in the gasoline synthesis. If the spent catalyst is extracted and decomposed with acid, the decomposition products of the carbides are obtained in the form of different hydrocarbons.

In an investigation of the influence of pressure upon the catalysts and the products of normal pressure synthesis, Fisher and Pichler established that nickel catalyst, with its tendency toward hydrogenation even at normal pressures, is not suitable for synthesizing liquid hydrocarbons. At high pressures, it forms nickel carbonyl with the carbon monoxide of the synthesis gas and is gradually carried out of the catalyst chamber. Under 50 atm. of pressure, cobalt does not form the carbonyl, but

If your responsibility is **MAINTENANCE*** read this

*corrosion control

Premise: ***Plastics*** **do not corrode.**

Premise: **CO-RES-CO permanently bonds a *plastic* coating to any metallic surface.**

Conclusion: **To combat corrosion effectively, economically, use CO-RES-CO the *plastic* corrosion resistant coating.**

Data

For busy plant executives and engineers:

CO-RES-CO IS NOT A PAINT. It is a *plastic* solution in a hydro-carbon vehicle.

CO-RES-CO DOES NOT OXIDIZE. It demonstrates many times greater resistance to severe acid, alkali, salt spray and to general weathering than can be expected from any of the oxidizing paints.

CO-RES-CO EMPLOYS NO DRYERS. (To whatever extent dryers are used in the paint film, the paint is weakened exactly to that extent.)

CO-RES-CO IS WIDELY USED. It is an accepted method of corrosion control in many industries and official government departments.

WRITE for further data, giving details of your corrosion and maintenance problems for specific analysis.

CORDO CHEMICAL CORP • Norwalk, Conn.
(Formerly: Corrosion Control Corp.)

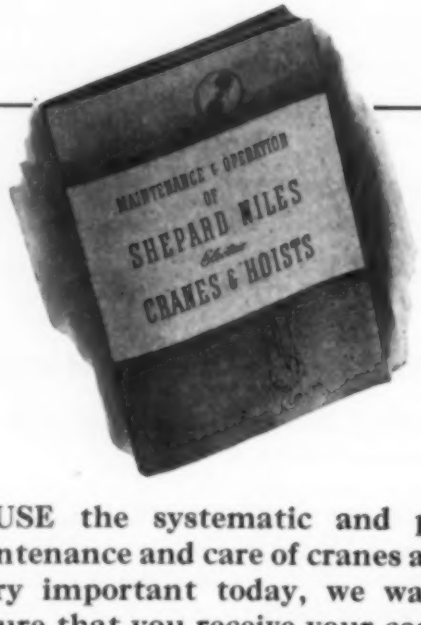
CO-RES-CO

THE PLASTIC CORROSION RESISTANT COATING

second call

FOR THOSE WHO MISSED OUR ORIGINAL OFFER TO SEND THE SHEPARD NILES MANUAL ON THE MAINTENANCE AND OPERATION OF ELECTRIC

cranes and hoists



BECAUSE the systematic and periodical maintenance and care of cranes and hoists is so very important today, we want to be doubly sure that you receive your copy of this manual, devoted to the Maintenance and Operation of Shepard Niles Electric Cranes & Hoists. If you missed our first offer, send for your copy *today*—you may need it *tomorrow*.

WRITE FOR YOUR COPY TODAY
YOU MAY NEED IT TOMORROW

106 pages—amply illustrated with sectional views and line drawings. . . . Covers the complete line of Shepard Niles Electric Cranes & Hoists. Sturdy, flexible cover. Special binding for easy opening. Convenient (7¼" x 10¾") size.

Shepard Niles
CRANE & HOIST CORPORATION

382 SCHUYLER AVE. • MONTOUR FALLS, N. Y.

above 100 atmospheres carbonyl formation occurs and the catalyst is consumed. A pressure of about 10 atm. resulted in the best yield of solid paraffins, the best total yield and the maximum catalyst life. At moderate pressures, iron catalyst will produce about the same yield as cobalt.

Digest from "Syntheses from Carbon Monoxide and Hydrogen" by Franz Fischer, Mülheim-Ruhr, *Oel and Kohle* **39**, 517-22, 1943. (Published in Germany.)

FIREPROOFING WOOD

IMPREGNATION fireproofing of wood is carried out by immersion and by pressure processes. In the immersion process the wood is placed in a tank of fireproofing solution maintained at 190-200 deg. F. for about three hours. The solution is allowed to cool and during cooling is drawn into the wood. Ammonium sulphate is usually the base of immersion solutions but other substances are employed. A total soaking time up to 48 hr. is necessary for good penetration.

In pressure treatment, the process is practically identical with that used for timber creosoting. The wood is placed in the treating cylinder, submitted to steaming and vacuum treatment and then impregnated with fireproofing solution under hydraulic pressure. Air and kiln drying of the wood complete the process.

The pressure process is effective but expensive, and suffers from the drawback that it must be carried out at a central site. Improved methods have, however, reduced retention time to a fraction of that formerly necessary. Plywood now needs only six to ten days and solid timber 10 days or more according to thickness and species.

Numerous chemicals have been proposed as fireproofing agents, and about 35 have been found to be fire resistant. These are mainly inorganic compounds, but a few organic substances have been tested, including hexachlorobenzene in o-dichlorobenzene. The following are some of the chemicals used:

Chlorides	ammonium, calcium, zinc, cupric,* magnesium
Sulphates	ammonium, aluminum, nickel
Borates	ammonium
Biborates	sodium
Phosphates	mono and diammonium, zinc,* nickel,* magnesium
Arsenate	sodium *
Acids	boric,* phosphoric.

* Toxic to wood-destroying fungus.

Some of these chemicals are used alone. Mixtures are also employed, for example: 70 parts of borax and 30 parts of monoammonium phosphate; 80 parts of diammonium phosphate and 20 parts of boric acid; 50 parts of zinc chloride and 40 parts of monoammonium phosphate plus 10 parts of ammonia gas.

Mono and di-ammonium phosphates are excellent for fireproofing; they stop flame and after-glow even in low concentrations, have no corrosive action on metals after the first effect that gives a protective coating, are not hydroscopic under normal conditions, and if well impregnated have a retention of about 75 percent after water leaching.

Digest from "The Fireproofing of Wood" by Norman Clarke Jones, *Chemistry and Industry*, No. 11, 98-99, 1944. (Published in England.)

CHEMICAL ENGINEER'S BOOKSHELF

LESTER B. POPE, Assistant Editor

ENGINEERING CHEMISTRY

INDUSTRIAL CHEMISTRY. *Third Edition. By William T. Read. Published by John Wiley & Sons, New York, N. Y. 631 pages. Price $5.*

Reviewed by John R. Callaham

TO THE undergraduate student of industrial chemistry, the third edition of Dr. Read's book will serve as a lucid and authoritative introduction to our modern chemical and process industries. Well written and not burdened with masses of secondary details, the work covers the principal chemical raw materials, processes and products of industry and relates these to basic economics and chemical engineering operations.

Particularly educational to the student are the beginning chapters "Relation of Chemistry to Industry," "The Work of Chemists and Chemical Engineers," "Chemical Organizations," "Sources of Information," and "Chemical Economics." In these sections Dr. Read, now doing valuable work with the National Roster of Scientific and Specialized Personnel of the War Manpower Commission, defines the chemical and process industries and makes clear the manner in which economics dominate the very existence of these industries, their component parts and individual units.

After differentiating between the work of the chemist and that of the chemical engineer, the author proceeds to deal with the two phases of preparing chemists and chemical engineers for industry that are most often neglected—chemical organizations, their purpose and practical value; and published sources of chemical information, their scope and proper use. Quite properly, modern advertising is pointed out as being a most valuable and accurate fund of information. It is hoped that what few chemical students remain in our schools and colleges will learn to use effectively these two valuable tools.

BRIMSTONE

THE ORGANIC CHEMISTRY OF SULFUR. *By Chester M. Suter. Published by John Wiley & Sons, New York, N. Y. 858 pages. Price $10.*

Reviewed by R. Fanelli

THE SUBJECT matter of this book is the organic derivatives of sulphuric acid and covers in a comprehensive way the esters of sulphuric acid, the aliphatic and aromatic sulphonic acids, their derivatives and related compounds.

Methods of preparation, reactions, properties, physical data, uses, etc., are given in some detail for a large number of compounds. Each statement appears to be supported by at least one reference. Consequently, the bibliography is extensive and complete. Graphic formulas and charts are numerous and are of great value to the reader.

Compounds of medicinal interest, such as the sulfonhaloamides, sulfanilamides, saccharin, etc., are discussed in detail. About twenty pages are devoted to saccharin and related compounds. The sulfanilamides and their derivatives received comparatively brief treatment. In view of the present importance of these compounds, more space might have been devoted to them. The references to these, however, are extensive.

The size of type and line spacing is such that easy reading of the context is assured. The structural formulas and charts are clear and of good size. The tables have been but slightly reduced with respect to size of type. A laudable departure is the printing of the references at the end of the chapters in large, easily read letters.

The book is a valuable addition to the chemical literature and the author is to be commended for assembling and arranging such a mass of detailed information. The title of the book is somewhat misleading in that one expects to find under such a title other organic surphur compounds besides the derivatives of sulphuric acid. The author, however, in the preface holds out the hope that another volume may be forthcoming to include the remainder of sulphur chemistry. Such a volume is needed, and it is hoped that the author will go ahead with its preparation.

RECENT BOOKS RECEIVED

Chemical Engineering Nomographs. By D. S. Davis. McGraw-Hill. $3.50.

Control of Electric Motors. 2nd ed. By P. B. Harwood. Wiley. $5.

Conveyors and Related Equipment. By W. G. Hudson. Wiley. $5.

Infrared Spectroscopy. By R. B. Barnes, R. C. Gore, U. Liddel & V. Z. Williams. Reinhold. $2.25.

Magnesium, Its Production and Use. By E. V. Pannell. Pitman. $4.

More About Acids and Bases. By D. Davidson, W. F. Luder & others. *Journal of Chemical Education.*

ELASTOMERS

MODERN SYNTHETIC RUBBERS. *Second Edition. By Harry Barron. Published by D. Van Nostrand Co., New York, N. Y. 355 pages. Price $6.50.*

Reviewed by James A. Lee

NEVER having seen the first edition of this work, which appeared at the time the Baruch Report was made public, it is necessary for me to give you the author's own comments regarding the modifications and improvements of this new edition. He writes in the new preface that in these days events move so rapidly under the pressure of war conditions that by the time the first edition had been published it was already out-of-date. A flood of developments in the United States made it necessary to begin at once to revise and enlarge the earlier volume. This he has done.

This time he has had better luck for the synthetic rubber industry has settled down somewhat. While there are still numerous developments their number has tended to diminish.

While the book deals principally with synthetic rubber, the natural material necessarily comes in for considerable discussion. In fact, the author has much to say of interest regarding the future of natural rubber. He warns his fellow Britishers that it may never return to its prewar position.

While his own country has been content to let others develop the synthetic rubber industry he appears to have a thorough knowledge of the progress that is being made in the United States, and to some extent that in Russia and other countries, which is no simple matter in these times of censorship.

Just about every phase of the industry is covered by Mr. Barron. The economics of these new materials are discussed at length. Raw materials come in for their share of attention. All of the elastomers that are now made on a commercial scale in the United States are treated, methods of manufacture, characteristics and applications.

PLASTICS CHEMISTRY

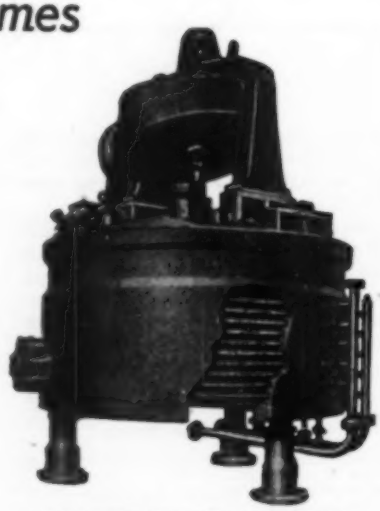
SYNTHETIC RESINS AND RUBBERS. *By Paul O. Powers. Published by John Wiley & Sons, New York, N. Y. 296 pages. Price $3.*

Reviewed by Chaplin Tyler

FOR 20 years, at irregular intervals, the reviewer has been privileged to interpret books for *Chem. & Met.* In this period, Dr. Powers' recent work stands out as one of the best, especially so because the rapidity with which the synthetic resins art is advancing makes an author's task difficult. Dr. Powers has achieved a balanced book in that theory and industrial practice are covered in good proportion. All major classes of synthetic resins and elastomers are covered adequately, including the condensation polymers, vinyl polymers, synthetic rubbers, and modifications of natural polymers. In each class, the basic chemistry, manufacture, and important applications are discussed. The book

Efficient Heat Transfer increases life of stills *five times*

Bethlehem Thermocoil units, replacing direct-fired retorts, also improve production flow, lower temperature requirements, and increase safety of operation.



Note how steel steam coils are cast integral with vessel walls to give uniform heat distribution.

A chemical manufacturer found direct-fired retorts unsatisfactory and costly in processing a certain sensitive, corrosive chemical by-product. Their life varied from two months to a year. Their uneven temperatures and tendency to hot spots aggravated the corrosion hazard. Unpredictable failures made it difficult to schedule production, increased the danger of operation, and resulted in frequent shut-downs.

Replaces with Thermocoil

Finally, when one badly corroded direct-fired unit failed, a Bethlehem Thermocoil retort was installed with immediate improvement in efficiency rates, temperature control, and fuel economy. Ten months later Thermocoil replaced a second direct-fired failure.

The average experience with these two Thermocoil units using steam as a heating medium, has demonstrated a life span more than FIVE TIMES THE LONGEST LIFE of any direct-fired retort previously used in this evaporation.

The Thermocoil also eliminates the need to cool down units for charging new batches, saving considerable time and operating labor.

Here's why Thermocoil Lasts Longer, Works Better

The steam coils in Thermocoil vessels for evaporating, distilling, and drying processes are integral parts of the vessel walls, cast right into them, as illustrated in the photograph.

They heat the entire wall surface evenly, eliminate hot spots, permit precise temperature control, save product from spoilage in process, effect notable heat economies.

For more complete information about Thermocoil advantages, send for Bethlehem Catalog No. 439. This 54-page booklet describes the *Hows* and *Whys* of Thermocoil operation. It also describes other Bethlehem processing equipment, including the Bethlehem Wedge Roaster, nitrators, reducers, suphonators, mixing kettles, vacuum stills, autoclaves, with structural details and capacity charts.

BETHLEHEM FOUNDRY & MACHINE COMPANY

BETHLEHEM, PA.

reflects the author's wide industrial experience and is at the same time academically sound. The book should be equally useful in the classroom and in industry.

AMATEUR MICROSCOPY

THE MICROSCOPE AND ITS USE. *By F. J. Munoz and H. A. Charipper. Published by Chemical Publishing Co., Brooklyn, N. Y. 334 pages. Price $2.50.*

HISTORY, instruments, accessories and techniques are presented in this book which is intended to be a reference midway between the instructions in manufacturers' literature and the theories of advanced treatises. The authors successfully present accurate instructions and sound advice while keeping to a minimum the discussions of theory and optics. For the hobbyist and student the book is recommended as a not-too-expensive guide. Paper and printing are good and numerous illustrations are included. The few typographical errors are disconcerting but not important.

RECENT BOOKS & PAMPHLETS

Index to A.S.T.M. Standards. Published by the American Society for Testing Materials, 260 S. Broad St., Philadelphia 2, Pa. 191 pages. Annual index of standards including tentative standards.

The Natural Resources of South Carolina. Bulletin No. 3 revised, prepared by South Carolina State Planning Board, Columbia, S. C. 115 pages. Climate, water, power, minerals and forest resources of the state.

Active Carbon in the Decolorizing, Deodorizing and Purifying of Oils, Fats and Related Products. Edited by John P. Harris. Published by Industrial Chemical Sales, 230 Park Ave., New York 17, N. Y. 42 pages. Technology of application of adsorptive carbon to fats, oils and related products.

Fundamentals of Coal Sampling. By B. A. Landry. Bulletin 454, Bureau of Mines. Available from Superintendent of Documents, Washington, D. C. 127 pages. Price 20 cents. Coal sampling theory and application.

Review of Iron and Steel Literature for 1943. By E. H. McClelland. Published by Carnegie Library of Pittsburgh. 23 pages. Classified list of books, serials and trade publications.

A Table of Common Hazardous Chemicals. Published by National Fire Protection Association, 60 Batterymarch St., Boston 10, Mass. 31 pages. Price 30 cents. Seventh edition which includes data on 98 chemicals.

The Use of Sulphur in the Control of Truck Crop and Cane Fruit Insects and Diseases. Compiled by A. Fenton and F. W. Clark. Published by Texas Gulf Sulphur Co., Houston 2, Texas. 85 pages. Gratis. Excerpts from authenticated sources on the beneficial results derived from the use of sulphur.

Synthetic Menthol. Published by Givaudan-Delawanna, Inc., 330 West 42nd St., New York 18, N. Y. 238 pages. Gratis. A collection of the literature (English and German) concerning pharmaceutical properties and use of synthetic menthol.

Guide to Postwar Products Development. Published by National Association of Manufacturers, 14 West 49th St., New York 20, N. Y. 14 pages. Suggests constructive action by management to develop new products both for self-interest and for improvement of the American standard of living.

Research Publications, 1940-41. Vol. IV part III. Published by Polytechnic Institute of Brooklyn, 99 Livingston St., Brooklyn, N. Y. 76 pages. Price 25 cents. Reprints of articles published by members of the faculty of the department of chemical engineering.

Natural and Synthetic Fibers. Published by Inter-Science Publishers, 215 Fourth Ave., New York, N. Y. Price $60 per year. An abstract service of 12 issues per year to cover the field

WATER
WILL BE AN URGENT POSTWAR NEED

Maybe it is entirely too early to order your postwar Water System. Maybe you can't even determine the amount of water you may need. But you do know that you are going to be pretty "hard boiled" about such things as long-life quality—top flight efficiency—and extra low operation cost.

Summing it up, you are going to demand the very features that have made Layne Water Systems world famous. But you are not going to buy on reputation alone. You are going to ask for a lot of bed-rock facts and figures. You will want to know exactly what you are getting for your dollars.

Fortunately, you are going to be the very kind of prospect that Layne likes to meet—the kind of buyer that will understand and fully appreciate the incomparably fine features found only in Layne Turbine Pumps and Water Systems. You are going to be a dandy postwar customer, and like hundreds of other "look before you leap" buyers, you are going to be a 100 percent satisfied Layne customer.

For literature and further facts, address Layne & Bowler, Inc., General Offices, Memphis (8), Tenn.

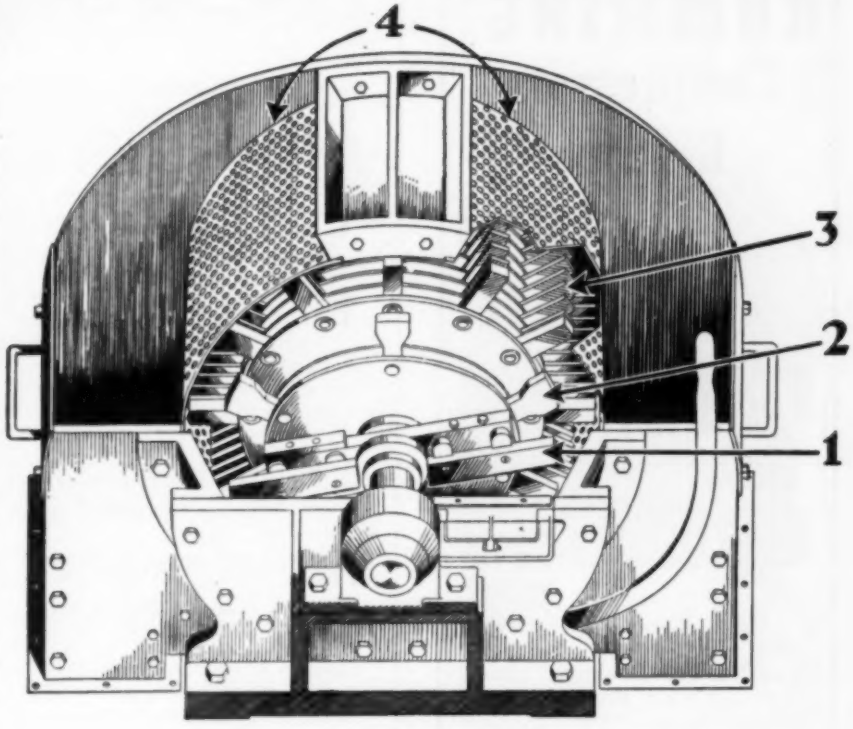
AFFILIATED COMPANIES: Layne-Arkansas Co., Stuttgart, Ark. • Layne-Atlantic Co., Norfolk, Va. • Layne-Central Co., Memphis, Tenn. • Layne-Northern Co., Mishawaka, Ind. • Layne-Louisiana Co., Lake Charles, La. • Louisiana Well Co., Monroe, La. • Layne-New York Co., New York City • Layne-Northwest Co., Milwaukee, Wis. • Layne-Ohio Co., Columbus, Ohio • Layne-Texas Co., Houston, Texas • Layne-Western Co., Kansas City, Mo. • Layne-Western Co. of Minnesota, Minneapolis, Minn. • International Water Supply Ltd., London, Ontario, Canada

LAYNE

WELL WATER SYSTEMS
DEEP WELL PUMPS

BUILDERS OF WELL WATER SYSTEMS FOR INDUSTRIES AND MUNICIPALITIES

DUAL SCREENS



AND

DUAL DRUMS

The dual screens of the Prater Gradual Reduction Grinder (4) definitely increases screening area from the usual 45% of the ordinary mill to 70% of grinding area. Also, the screens can be more efficiently designed. There is no need for reinforcing the Prater Screens against the shocks of material in the breaking (1) and crushing (2) stages. That is all done in the primary drum, where the materials bounce against tough steel castings.

Then the crushed material is fed around the entire periphery of the rotor to the final sizing blades (3) of the main grinding drum. The particle size is such that the greater part of the area can be devoted to screening. Because the dual screens are away from preliminary breaking and crushing they can be designed for true screening efficiency, as there are no large and heavy particles hammering the dual screens. This hammering in the usual mill distorts the screens and lowers screening efficiency still further.

The immediate value of the 70% screening area is immediately apparent to the grinding engineer — but there are many other factors in this principle of dual screens and dual drums, that are worthy of the study by the man interested in production control and low power cost.

Write for information.

Address:

PRATER
PULVERIZER COMPANY
1825 S. 52nd AVE. **CHICAGO, 50, ILLINOIS**

Or

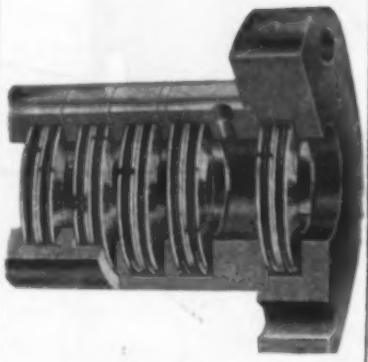
BROWN & SITES COMPANY
50 CHURCH STREET **NEW YORK, NEW YORK**

KEEP 'EM HUMMING!

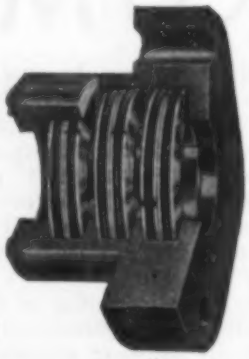
✓ Compressors

✓ Engines

✓ Pumps



Type No. 270. Designed especially for gas compressors. France Metal "Full-Floating" Packing is outstanding for its long wearing qualities. Eliminates frequent shut-downs.



Type No. 190. Designed for shallow stuffing boxes and prevents condensation from entering the crankcase. Prompt delivery assured.

Specify the packing that L-A-S-T-S—FRANCE "Full-Floating" Metal Packing. Ask for catalog No. M-4.

THE FRANCE PACKING COMPANY

Tacony, Philadelphia 35, Penna.

Branch Offices in Principal Cities

Original FRANCE METAL PACKING

of chemical and physical structure of fibers, the intrinsic properties of fibers and fabrics and the processing of fabrics based on these properties. First issue (64 pages) contains table of contents and a number of abstracts from American, British and German periodicals and patents.

Annual Report. Published by Engineers' Council for Professional Development, 29 West 39th St., New York, 18, N. Y. 52 pages. Eleventh annual report for the year ending Sept. 30, 1943.

Health on the Production Front. Published by National Association of Manufacturers, 14 West 49th Street, New York 20, N. Y. 80 pages. Ways of improving efficiency, reducing absenteeism, lowering labor turnover and preventing accidents. Prepared as a reference manual to aid management in the compilation of manpower through good health practices.

Ultimate Strength of Reinforced Concrete Sheets as Related to the Plasticity Ratio of Concrete. By Vernon T. Jensen. Bulletin Series No. 345, published by the University of Illinois, Urbana, Ill. 60 pages. Price 70 cents. Formulas are derived for the ultimate strength of beams reinforced tension only. Comparisons are made with the results of tests that have been reported by various investigators.

Mechanical Feedwater Regulation for Boilers. Sixth edition. By E. P. Culver. Published by Northern Equipment Co., 1945 Grove Drive, Erie, Pa. 28 pages giving principles of boiler feedwater control and mechanical equipment available to meet various operating conditions.

GOVERNMENT PUBLICATIONS

The following recently issued documents are available at prices indicated from Superintendent of Documents, Government Printing Office, Washington, D. C. In ordering any publications noted in this list always give the complete title and the issuing office. Remittances should be made by postal money order, coupons, or check. Do not send postage stamps. All publications are in paper covers unless otherwise specified. When no price is indicated, the pamphlet is free and should be ordered from the Bureau responsible for its issue.

Excess Profits Tax under the Internal Revenue Code as Amended (for Taxable Years Beginning After December 31, 1941), Regulations 112. Bureau of Internal Revenue. Price 45 cents.

Trade Agreement Between the United States and Iceland. U. S. Tariff Commission.

The Rayon Industry. Most of the data relates to the period before 1939. U. S. Tariff Commission.

Highlights of Population Shifts, March 1944. War Food Administration. Mimeographed.

Report of the Secretary of Agriculture, 1943. Department of Agriculture. Price 30 cents.

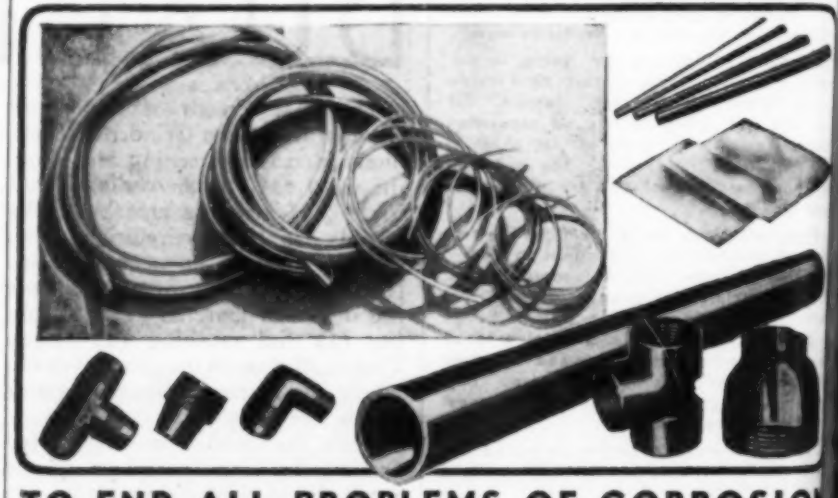
Report on the Agricultural Experiment Stations, 1943. By J. T. Jardine and others. Agricultural Research Administration. Price 2[illegible] cents.

Principles and Methods in the Canning of Fishery Products. Research Report No. [illegible] By Norman D. Jarvis. Available only from U. S. Fish & Wildlife Service, Merchandise Mart, Chicago, Illinois.

Educational Directory, 1943-44; Part III Colleges and Universities. U. S. Office of Education. Price 20 cents.

Tungsten Deposits, Isle de Pinos, Cuba. By L. R. Page and J. F. McAllister. U. S. Geological Survey, Bulletin 935-D. Price $1.25.

Manganese Deposits in the Artillery Mou[illegible]



TO END ALL PROBLEMS OF CORROSION

Saran is a tough thermoplastic originally made to replace such strategic war materials as aluminum, stainless steel, nickel, copper, brass, tin and rubber. Now found adaptable to a wide range of uses in product designing, food processing and wherever non-corrosive materials are necessary. Its insulating qualities, flexibility and ease of handling make it extremely valuable in installations dealing with oils, gases, air, water and corrosive chemicals. It is available in tube, pipe, sheet, rod and molded fittings. Technical Bulletin P-8 will be sent on request. Address Dept. A.

Pat. No. 2160931

SARAN

HODGMAN RUBBER CO.

FRAMINGHAM, MASS.

NEW YORK . . . 261 Fifth Avenue

CHICAGO . . . 412 South Wells St.

SAN FRANCISCO . . . 121 Second St.

Industry's First Choice Since '31

General Controls' K-3B is a versatile magnetic gas valve. It has a wide acceptance for use in controlling gas to heat-treating ovens, boilers, furnaces, and similar industrial installations. Write for Catalog 52 for full description specifications.

- Available in widest range of sizes, from ⅜" to 6" I.P.S.
- For operating pressure up to 5 pounds.
- Unusually low in current consumption.
- For all voltages and frequencies, A.C. or D.C.
- Quiet, positive and trouble-free operation.

GENERAL CONTROLS

801 ALLEN AVENUE • GLENDALE 1, CALIF.

BRANCHES: Boston, New York, Philadelphia, Cleveland, Detroit, Denver, Chicago, Dallas and San Francisco

BUMP PUMPS SOLVE YOUR WARTIME PUMP PROBLEM

POSITIVE ACTION

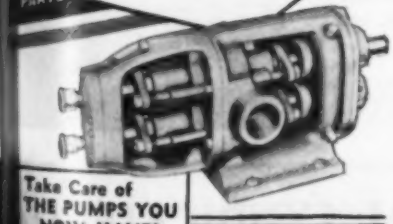
SLOW SPEEDS

Many chemical process plants are finding BUMP PUMPS completely solve their wartime problems. BUMP PUMPS are positive displacement type that operate at slow speeds, are self-priming under high vacuums or against head pressures, delivering a constant volume per revolution that is not affected by speed or pressures. Economical in use and maintenance. Sizes for every plant requirement. Catalog and engineering data upon request.

SELF PRIMING

NO PURRING ACTION

ONLY TWO MOVING PARTS



Take Care of THE PUMPS YOU NOW HAVE!

The BUMP PUMP CO.

LA CROSSE • WISCONSIN

tains Region, Mohave County, Arizona. By S. G. Lasky and B. N. Webber. Geological Survey, Bulletin 936-R. Price $1.25.

Geology of the Coastal Plain of Georgia. U. S. Geological Survey Bulletin 941. Price $1.25.

Water-Table Fluctuations in the Spokane Valley and Contiguous Area Washington-Idaho. U. S. Geological Survey Water-Supply Paper 889-B. Price 30 cents.

Coal-Mine Accidents in the United States: 1941. By W. W. Adams and L. E. Geyer. Bureau of Mines, Bulletin 456. Price 20 cents.

Coke-Oven Accidents in the United States, Calendar Year 1942. By W. W. Adams and V. E. Wrenn. Bureau of Mines, Technical Paper 660. Price 10 cents.

Low-Temperature Distillation Yields of Primary Tar and Light Oil from Coals of Various Ranks and Types. By W. H. Ode and W. A. Selvig. Bureau of Mines, Report of Investigations R. I. 3748. Mimeographed.

Equilibria in the Reduction of Chromic Oxide by Carbon, and Their Relation to the Decarburization of Chromium and Ferrochrome. By F. S. Boericke. Bureau of Mines, Report of Investigations R. I. 3747. Mimeographed.

Mineral Data. Summaries of 1943 production of numerous non-metallic minerals are now available, in addition to the major metals reports. Items issued recently include kaolin, fluorspar, lime, explosives, aluminum, and magnesium (1942). Bureau of Mines. Mimeographed.

Ground Water Supply for Military Operations. War Department, Technical Manual TM 5-296. Price 15 cents.

Mobile Oxygen-Nitrogen Generating Units. War Department, Technical Manual TM 5-355. Price 20 cents.

Purchase by the United States of exportable surpluses of Dominican rice, corn, and peanut meal, agreement between the United States of America and the Dominican Republic, approving memorandum of understanding dated May 20, 1943, effected by exchange of notes, signed at Ciudad Trujillo, June 10, 1943. State Department, Executive Agreement Series 350. Price 5 cents.

390 Bills, a Digest of Proposals Considered in Congress in Behalf of Small Business 1933-1942. Commerce Department, Economic Series No. 27. Price 20 cents.

Foreign Trade Data. Censorship has been relaxed for many data on imports and exports of the United States. Previously such figures have been withheld from publication, but now available are the figures for the last three months of 1941 in "Monthly Summary of Foreign Commerce of the United States". Included in the December issue of that periodical is the summary for the twelve months of that calendar year. Also available from the Department of Commerce are preliminary releases of figures on exports of domestic merchandise and imports for consumption, which make up the two principal tables in what will ultimately be the bound volume, "Foreign Commerce and Navigation of the United States for the Calendar Year 1941." These two summaries give data arranged by country of origin or country of destination for each of the major commodities reported.

Columbia River and Its Tributaries. The first four parts of a series of hearings before a subcommittee of the House Committee on Irrigation and Reclamation, under H. Res. 262, are now available. These give water supply and power possibility information for certain sections of the Columbia River. Prices: Part 1, $1.25; Part 2, 65 cents; Part 3, 65 cents; Part 4, 75 cents.

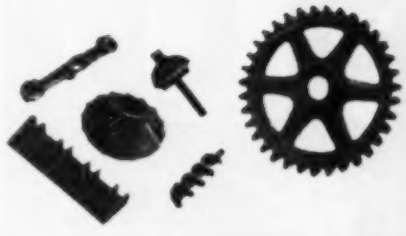
Plastics for Aircraft. Army-Navy-Civil Committee on Aircraft. Bulletin No. ANC-17. Price 40 cents.

Plastics Specifications. Specifications for sampling and testing of organic plastic materials are given in Federal Specification L-P-406a. Price 15 cents.

Wood Preservative Specifications. Extensive revision has been made of certain portions of the numerous Federal Specifications for wood preservative materials. Those interested in individual types should secure the following Federal Specifications and recent amendments: celcure (acid-cupric-chromate), TT-W-546; chromated-zinc-chloride, TT-W-551; coal-tar-creosote, TT-W-556a; creosote-petroleum-solution, TT-W-568; recommended treating practice, TT-W-571b; Wolmansalt (tanalith), TT-W-573. Individual Specifications are 5 cents each.

STAINLESS STEEL CASTINGS

Resistant to Acid Corrosion and Heat



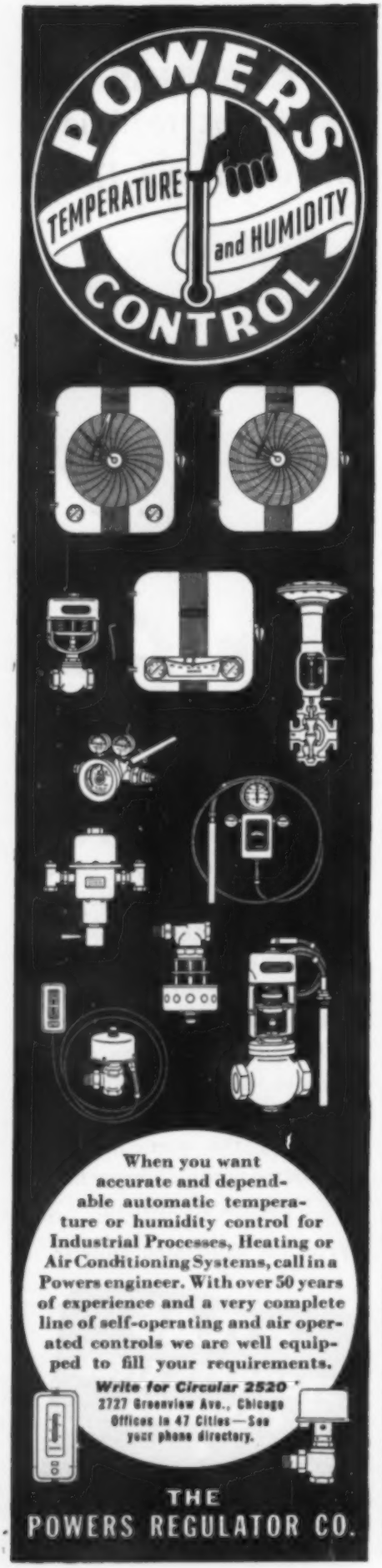
In the manufacture of Stainless Steel Castings it is important to know how! Atlas metallurgists have been specializing in the casting of corrosion resistant alloys for over 20 years, and have pioneered many of the revolutionary methods used today for casting corrosion resisting alloys. Every Atlas Stainless Steel casting is designed purposely for the particular job. Atlas foundrymen do know how! Your inquiries are invited.

Write for illustrated bulletin.

ATLAS STAINLESS STEEL CASTINGS

Division Atlas Foundry Co.

540 LYONS AVE. IRVINGTON, N. J.



When you want accurate and dependable automatic temperature or humidity control for Industrial Processes, Heating or Air Conditioning Systems, call in a Powers engineer. With over 50 years of experience and a very complete line of self-operating and air operated controls we are well equipped to fill your requirements.

Write for Circular 2520

2727 Greenview Ave., Chicago
Offices in 47 Cities—See your phone directory.

THE POWERS REGULATOR CO.

MANUFACTURERS' LATEST PUBLICATIONS

Publications listed here are available from the manufacturers themselves, without cost unless a price is specifically mentioned. To limit the circulation of their literature to responsible engineers, production men and industrial executives, manufacturers usually specify that requests be made on business letterhead.

Aluminum. Aluminum Company of America, Pittsburgh, Pa.—24-page illustrated pamphlet presenting twelve economic advantages of aluminum with numerous examples of things which have been "imagineered" into aluminum actualities.

Ball Bearings. New Departure, Division General Motors Corp., Bristol, Conn.—16-page illustrated booklet entitled "Making Them 'Round'." It describes how the steel balls are made and their use in ball bearings. Bulletin A-81.

Boilers, Department "M", Foster Wheeler Corp., 165 Broadway, New York 6, N. Y.—28-page spiral bound booklet illustrating and describing the S-A type boiler. Includes drawings, photographs, operating data and details of construction as well as a chart on the heat content of steam. Bulletin B-44-5.

Business Engineering. George S. May Business Foundation, 111 South Dearborn St., Chicago 3, Ill.—8-page report, "How Business Engineering Benefits Business," explaining the various phases of business engineering as applied to all component factors of production, management, and marketing. Report No. 149.

Business Institute. Carrier Institute of Business, Carrier Corp., Syracuse, N. Y.—32-page illustrated booklet dealing with the background and method of operation of the "Carrier Institute of Business," a venture in employee education which has attracted attention among industrial companies. Entitled "A 2-Way Street."

Cam Timers. Automatic Temperature Control Co., 34 East Logan St., Philadelphia 44, Pa.—4-page folder describing and illustrating the operating principles, types, construction design, and general applications of synchronous-motor-driven Cam Program Timers. Bulletin B7.

Centrifugal Castings. Pettibone Mulliken Corp., 4700 West Division St., Chicago 51, Ill.—12-page illustrated pamphlet describing this concern's line of centrifugal steel castings. Includes design data.

Combustion Control. Leeds & Northrup Co., 4934 Stenton Ave., Philadelphia 44, Pa.—37-page revised Metermax catalog showing some recent installations of the company's full-metered system of combustion control. Amply illustrated. Catalog N-O1M-163.

Compressed Air Cleaner. Logan Engineering Co., Chicago, Ill.—12-page illustrated booklet describing the application of the Aridifier in order to eliminate dirt, moisture, oil, fine scale, and other pollution that lessens compressed air efficiency. Includes tables and charts of useful information. Bulletin No. 543 A.

Compressors. Sullivan Machinery Co., Michigan City, Ind.—56-page illustrated bulletin presenting this company's line of heavy duty, two-stage, air-cooled compressors for industrial plants, mines, and heavy contracting. Includes installations, sizes, types, drives and construction detail, as well as information as to foundation requirements, regulation, accessories and servicing. Bulletin A-52.

Condensate-Purity Instruments. Leeds & Northrup Co., 4934 Stenton Ave., Philadelphia 44, Pa.—23-page illustrated revision of the catalog, Micromax Condensate-Purity Instruments for the Steam Plant." Includes tables of useful information and data on performance in typical installations. Catalog N-95-163.

Control System. Taylor Instrument Companies, Rochester, N. Y.—8-page bulletin covering the uses and the operating principles of the Fulscope Pneumatic Set Controller. Illustrated with simplified application drawings. Bulletin 98159.

VITREOSIL

IMMERSION HEATERS

Vitreosil Electric Immersion Heaters are of particular value in many instances where liquids of an acid reaction must be heated. For such applications, the Vitreosil envelope of the heating unit combines the advantages of being acid-proof, a good electrical insulator, and resistant to severe thermal shock.

Vitreosil (99.8% SiO_2) is unaffected by all halogens and acids, regardless of temperature or concentration, with the exception of fluorine, hydrofluoric and phosphoric acids.

Vitreosil Electric Heaters are available in lengths ranging from 10 to 30 inches with k.w. ratings of .25 to 5.0.

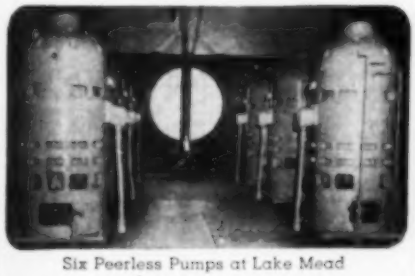
Write for full details and quotations on Vitreosil Electric Immersion Heaters.

VITREOUS SILICA — VITREOSIL

The THERMAL SYNDICATE, Ltd

12 East 46th Street **New York 17, N. Y.**

Making
MAGNESIUM
with
PEERLESS-PUMPED WATER



Six Peerless Pumps at Lake Mead

Pumps are installed on cantilever bridge

From Lake Mead to Basic Magnesium, Inc.

The colossal desert plant of Basic Magnesium near Las Vegas, Nevada, is making thousands of tons of "desert gold" annually for war use. When operating at peak capacity, Basic needs 100,000,000 gallons of water daily. It's Peerless' job to deliver this deluge of water. At Lake Mead, twelve miles away, six huge Peerless Pumps lift the water from the lake and boost it over mountain ridges and through desert stretches to the Basic plant. The direct-connected pumps (Peerless Turbine Type) are mounted on a special Cantilever bridge that reaches out over the lake to deep water. A typical war job that Peerless is proud to be a part of.

Peerless Pumps

PEERLESS PUMP DIVISION
Food Machinery Corporation
301 W. Ave. 26, Los Angeles 31, California
1250 W. Camden Ave., S.W., Canton 6, Ohio
Other Factories: San Jose 5, and Fresno 16, Calif.

A Third CITATION
FOR THE INSTRUMENT LEADER

FOR MERITORIOUS WAR PRODUCTION

This third citation for meritorious war production . . . climaxing a long record of war service . . . is a source of justifiable pride to the men and women of WESTON.

The record began back in the earliest days of our defense period, when a large segment of WESTON'S capacity was assigned to the production of instruments vital to military needs. Thus, when we finally were forced into this world struggle, WESTON was ready for *full-scale war production.*

This new star which adorns our "E" pennant marks the *third* time WESTON has been *first* in this highly specialized field to receive each successive war citation. Weston Electrical Instrument Corporation, Newark 5, New Jersey.

WESTON *Instruments*

know and plan with PQ silicates

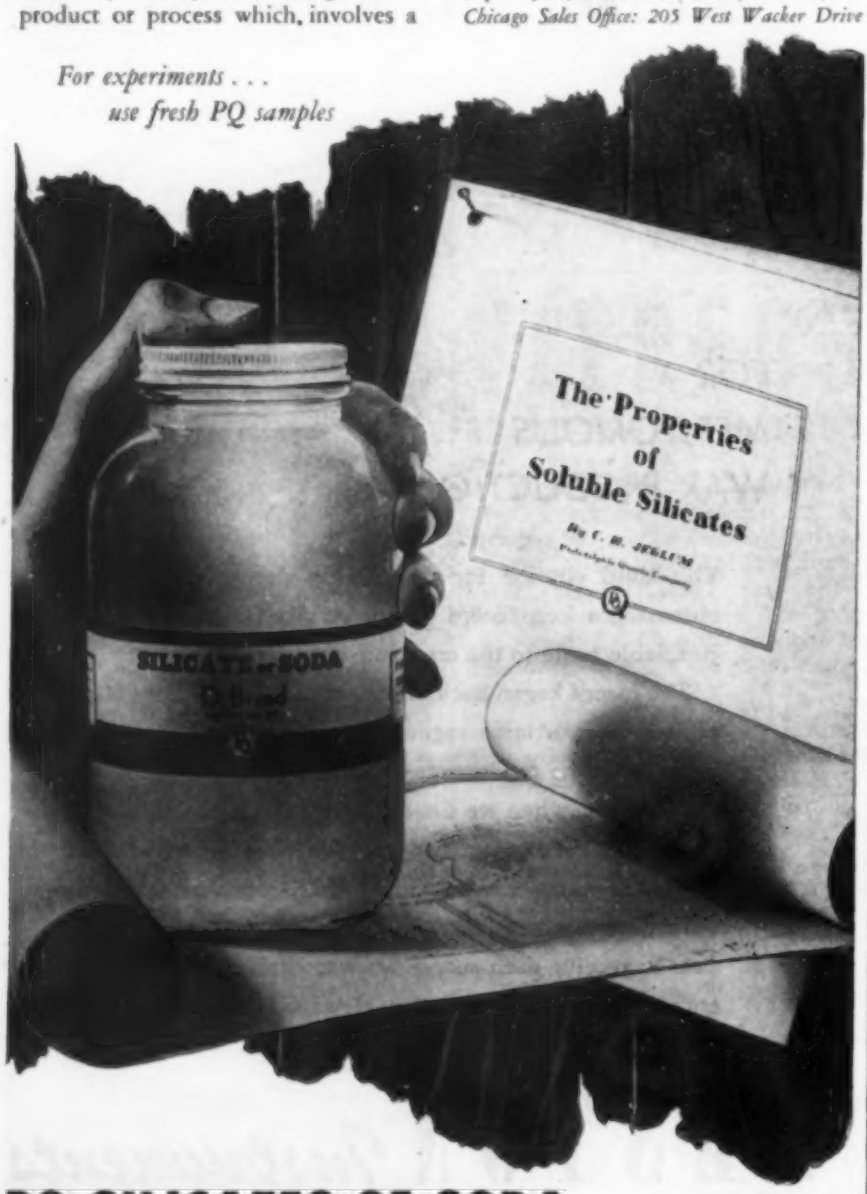
POST-WAR developers are taking a close-up view of PQ soluble silicates and their properties.

In the catalog of 50 grades are liquids, solids and powders which range from $3Na_2O$, $2SiO_2$ to Na_2O, $3.9SiO_2$. The variety is worth remembering for they provide an interesting array of characteristics useful to industry. Bul. 1703 mailed free on request reviews the pertinent facts of properties, grades and uses as adhesives, binders, detergents, gels, colloids, inhibitors, coagulants.

You may already be working with a product or process which, involves a sodium or potassium soluble silicate. Then make use of our silicate information service for data on your specific problem. PQ "know-how" of silicate manufacture and application technique has been accumulating for over 75 years. The many references to silicates in patents and literature in our files are a time-saver and help to investigators. This background is worth remembering too.

PHILADELPHIA QUARTZ CO.
Dept. A, 119 South Third Street, Phila. 6, Pa.
Chicago Sales Office: 205 West Wacker Drive

For experiments . . .
use fresh PQ samples



PQ SILICATES OF SODA

Conveyor Systems. Robinson Air-Activated Conveyor Systems, 205 East 42nd St., New York 17, N. Y.—4-page illustrated folder describing this concern's systems for conveyance of fine, granular or fibrous materials. Includes a list of installations of these conveyors. Bulletin 310.

Copper Plating Process. United Chromium, Inc., 51 East 42nd St., New York 17, N. Y.—6-page illustrated leaflet describing the characteristics and advantages of Unichrome Alkaline Copper Plating Process. Contains a plating speed table and other technical data.

Couplings. Farrel-Birmingham Co., Inc., 344 Vulcan St., Buffalo, N. Y.—8-page illustrated bulletin presenting Farrel Manger Couplings designed for applications where space limitations make a close-coupled connection necessary. Includes engineering details, application diagrams and tables of sizes, ratings and dimensions. Bulletin No. 446.

Degasification of Water. Cochrane Corp., 17th & Allegheny Ave., Philadelphia 32, Pa.—18-page illustrated booklet describing this concern's equipments that are available for removal of gases from water at various temperatures. Bulletin 4076.

Die Casting. The New Jersey Zinc Co., 160 Front St., New York 7, N. Y.—64-page revised edition of the bulletin, "Zamak Alloys for Zinc Alloy Die Casting." Includes technical data and tables of useful information.

Dust Suppression. Whiting Corp., Harvey, Ill.—11-page bulletin dealing with the collection and suppression of dust in industrial plants. Features the uses and application of Hydro-Clone dust suppressors. Includes charts and tables of useful information. Bulletin FY-129.

Electronics. Fansteel Metallurgical Corp., North Chicago, Ill.—16-page illustrated booklet entitled, "Electronics Begins in Metals." Includes information on tantalum, molybdenum, and tungsten, and their uses in a transmitter tube.

Electronic Tubes. Electronics Dept., General Electric, Schenectady, N. Y.—4-page data sheet containing a comprehensive list of electronic tubes for industrial use. Useful quick selection chart.

Gas Mask. Mine Safety Appliances Co., Braddock, Thomas and Meade Sts., Pittsburgh, Pa.—4-page illustrated folder dealing with "All-Service" Gas Masks, Model "S" and Standard Model. Bulletin No. EA-8.

Hard Rubber. The B. F. Goodrich Co., Akron, Ohio—4-page catalog section presenting applications of various hard rubber types, kinds of products which can be manufactured from the material, suggestions for machining and tables listing the properties of the types which the company makes, and dimensions and weights of sheets, rods, and tubing. Catalog section 9405.

Heat-Saving Device. Cochrane Corp., 17th & Allegheny Ave., Philadelphia, Pa.—12-page illustrated bulletin presenting this company's continuous blow-off systems, the advantages from the standpoint of regulating boiler concentrations, the type of equipment available for different heat balance requirements, as well as illustrations and photographs of installations and heat exchangers. Bulletin 4081.

High Speed Motion Pictures. McLarty Business Films, 986 Ellicott St., Buffalo 8, N. Y.—4-page folder describing ultra high speed motion pictures and their application to problems of engineering and scientific research.

Hydraulic Press. The Hydraulic Press Mfg. Co., Mount Gilead, Ohio—4-page folder describing and illustrating this concern's "Closed Circuit" Fastraverse System. More detailed information concerning this operating system is included in a 32-page illustrated bulletin 4400.

Industrial Jacks. Templeton, Kenly & Co., 1020 S. Central Ave., Chicago 44, Ill.—60-page illustrated catalog and manual of Simplex Lever, Screw and Hydraulic Jacks. Pictures, descriptions, dimensions, capacities and weights of hundreds of jacks are included. Catalog No. 44.

Materials Handling. The Revolvator Co., North Bergen, N. J.—12-page illustrated circular briefly describing the types and applications of Revolvator Portable Elevators in the art of piling in modern industry. Bulletin No. 139.

Materials Handling. Robins Conveyors, Inc., Passaic, N. J.—12-page illustrated pamphlet presenting this concern's Floatex Foundry Shakeouts. Describes standard, self-discharging, multiple unit and portable types, and includes design data. Bulletin No. 124-A.

Northeastern Ohio. The Cleveland Electric Illuminating Co., 75 Public Square, Cleveland 1, Ohio—8-page booklet entitled, "The Elements of a Successful Postwar Formula," presenting chemical information about the Cleveland and Northeastern Ohio area.

Pilot Plants. Foster Wheeler Corp., 165 Broadway, New York 6, N. Y.—24-page spiral bound booklet illustrating and briefly describing the principal features of the facilities of this concern's laboratory and pilot plants. Bulletin O-44-6.

Piping. Crane Co., 836 South Michigan Ave., Chicago 5, Ill.—32-page illustrated booklet entitled, "Piping Pointers for Industrial Maintenance Men," containing practical information on piping. Design and performance data as well as a glossary of piping terms included.

Prestressing. The Preload Co., 420 Lexington Ave., New York 17, N. Y.—8-page bulletin explaining the Preload method of prestressing. Includes tables of useful information.

Preventive Maintenance. George S. May Business Foundation, 111 South Dearborn St., Chicago 3, Ill.—6-page report entitled, "Preventive Maintenance in the Bottling Industry," dealing with machinery maintenance, many methods of which are applicable to other industries. Report No. 151.

Protective Coatings. Wailes Dove-Hermiston Corp., Westfield, N. J.—4-page folder covering maintenance problems in the paper and pulp industry, and the solutions claimed in the use of Bitumastic protective coatings.

Refractories. Basic Refractories, Inc., Cleveland 15, Ohio—4-page bulletin illustrating and describing Gunnix refractories and guns designed for rapid emplacement by air, steam and water. Bulletin GI-44.

Refrigeration. Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.—20-page illustrated booklet presenting Westinghouse air conditioning and industrial refrigeration for many industrial processes. Illustrates air conditioning and refrigeration equipment, and describes the Westinghouse Hermatically-sealed Compressor.

Regulators. Grove Regulator Co., 1190 67th St., Oakland, Calif.—16-page illustrated booklet covering Grove Powreactor Dome Regulators for air, gas, and liquids at high pressures. Design and performance data included as well as installation and operating instructions. Bulletin No. 123 A.

Sifters and Mixers. The J. H. Day Co., Cincinnati, Ohio—16-page illustrated pamphlet describing this concern's sifters, mixers, invincible mixers, cylindrical mixers, and jumbo mixers. Includes specification tables. Bulletin 354.

Speed Reducing Transmissions. D. O. James Mfg. Co., 1140 W. Monroe St., Chicago, Ill.—376 illustrated catalog covering gear speed reducers and cut gears. Design and performance data included. Deals with herringbone, planetary, spiral bevel, spiral bevel herringbone, spiral bevel planetary, worm gear and motorized gear speed reducers and flexible couplings. Catalog No. 1000R.

Steam Jet Vacuum Pumps. Schutte & Koerting Co., 12th & Thompson Sts., Philadelphia 22, Pa.—36-page bulletin of detailed descriptions of this concern's single- and multistage steam jet vacuum pumps in many sizes and types for low and high vacuum work. Sectional drawings show features of construction and principles of operation. Bulletin No. 5-EH.

Steam Pressure Cleaners. Tivit Products Co., 8024 South Vermont Ave., Los Angeles 44, Calif.—6-page folder presenting Tivit steam pressure cleaners.

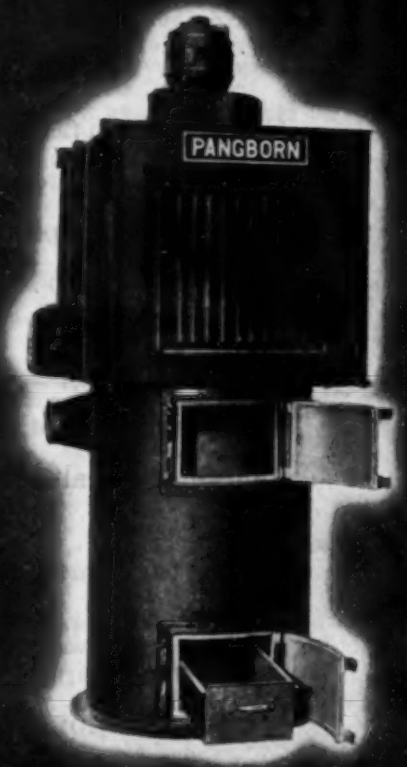
Synthetic Optical Crystals. The Harshaw Chemical Co., 1945 East 97th St., Cleveland, Ohio—16-page illustrated booklet describing synthetic optical crystals, their production and applications. Emphasizes their importance in infrared spectroscopy, which has proved of such value in helping develop and automatically control the manufacture of high octane gasoline and synthetic rubber.

Thermocouple Catalog. Wheelco Instruments Co., Harrison & Peoria Sts., Chicago 7, Ill.—36-page catalog and data book describing products, prices, and recommendations for Thermocouple users. Contains tables and data for selection, application design, and construction. Bulletin No. S2-4.

Valves. Grove Regulator Co., 1190 67th St., Oakland 8, Calif.—20-page illustrated bulletin covering this company's Flex Flo Remote Control Valve, its design and construction and its operation. Includes tables and diagrams of useful information. Bulletin No. 800.

« PROTECTION FOR PRODUCTION »

Something new in Dust Control equipment. A Unit Type Dust Collector of rugged construction for industrial applications, based on Pangborn's 40 years experience in solving dust problems throughout industry.



A FEW OF THE MANY NEW FEATURES

- Self-contained. Occupies minimum floor space.
- Flexible in arrangement to permit adaptation to variety of field conditions.
- Easily accessible for inspection, servicing and adjustment.
- Minimum piping and installation expense.

Arrangement details, operating data and photographs are available in Bulletin No. 910. A copy will be sent to you upon request—no obligation, of course!

ARMY E NAVY

PANGBORN

WORLD'S LARGEST MANUFACTURER OF DUST COLLECTING AND BLAST CLEANING EQUIPMENT

PANGBORN CORPORATION · HAGERSTOWN, MD.

sure, we can ship ortho-NITRODIPHENYL immediately!

If you are in need of ortho-Nitrodiphenyl, technical, for your current production or for experimentation in connection with a postwar product, you can get it promptly from Monsanto . . . and at a reasonable price.

Ortho-Nitrodiphenyl is widely used as an intermediate in chemical synthesis. In some such applications it is useful as an alternate for nitrobenzenes.

Your experimentation may reveal wide and varied uses for this low-priced intermediate. We shall be glad to send you samples for experimental purposes. MONSANTO CHEMICAL COMPANY, Organic Chemicals Division, 1700 South Second Street, St. Louis 4, Missouri. District Offices: New York, Chicago, Boston, Detroit, Charlotte, Birmingham, Los Angeles, San Francisco, Montreal, Toronto.

o-NITRODIPHENYL
(Technical)

Appearance: Light yellow to reddish crystalline solid.

Crystallizing Point: 34.5°C. Min.

MONSANTO CHEMICALS
SERVING INDUSTRY...WHICH SERVES MANKIND

CHEMICAL ECONOMICS

H. M. BATTERS, Market Editor

INDUSTRIAL CONSUMPTION TO CHEMICALS CONTINUES TO SHOW GAINS IN VOLUME

INDUSTRIAL production in general in the last four months has shown but little change but the rising trend has been checked and while month-by-month fluctuations are slight, the curve is tending downward. In the case of over-all production of chemicals, the downward movement is a little more accelerated, which is due largely to the cutback in the output of ammunition. While the munitions program for March reported an increase of 3 percent over February, the rate of ammunition output declined by the same percentage, which partially explains why the unadjusted index of the Federal Reserve Board stood at 360 in February and at 346 in March.

Reports that peak production of war materials has passed may prove somewhat premature in view of the statement made last month to the effect that WPB executives were still concentrating on war-production problems and that production must be stepped up by at least 10 percent by August if military needs are to be met. As an offset to some of the cutback in ammunition outputs, a recent order decreed that production schedules at an ordnance works in Wisconsin be increased. This meant the operation of two stand-by lines and also an expansion program entailing new building to a total of $24 million dollars. On the other hand, consumption of aluminum has been running below earlier estimates and this led to an order at the beginning of the month to close two production lines at a plant in New York. This action automatically cuts down demand for chemicals at that plant and this particularly affects soda ash of which upwards of 300,000 tons were consumed last year in the manufacture of alumina.

The synthetic rubber program has been coming along according to schedule. Production for the second quarter of this year will approximate 210,000 tons or roughly a 25 percent increase over the first quarter. In the *Chem. & Met.* index, rubber is maintained at a nominal figure because of the large part of current supplies which are reserved for war purposes but the use of chemicals in the rubber industry is steadily increasing and will reach its peak in the final quarter of the year. Furthermore, there is good reason to believe that when war demands are over, civilian needs for rubber products will maintain production at top levels. Natural rubber will not be in a competitive position for some time which gives assurance that the rubber industry will be more important as a consumer of chemicals than it has ever been in the past. Plastics are in a very much similar position as some types of production are entirely reserved for military use and practically all types are channeled to war industries to a varying degree but in general it is held that about 85 percent of all plastic production is going for war needs.

Referring to other large consumers of chemicals it is found that recent improvement has been made at textile, pulp and paper, and paint and varnish plants. Considerable pressure has been brought to bear to bring up outputs at textile mills but operators are not finding conditions any too favorable. At any rate mills have started to increase working hours and if the manpower question together with replacements for worn out equipment can be satisfactorily settled the outlook will have a greater appearance of stability.

Efforts to increase the supply of pulpwood have met with some success and in March 1,137,000 cords of domestic wood reached pulp mills. This total was further enlarged by receipts of 345,000 cords from Canada. While large, the gross supply for the first quarter of this year fell behind the quantity made available in the corresponding quarter of 1942. The drive to increase collections of waste paper has helped but, as in the case of pulpwood, the maintenance of large monthly supplies is necessary to keep production of paper and paperboard up to the level desired and there is no certainty that this regular flow of raw materials will be possible.

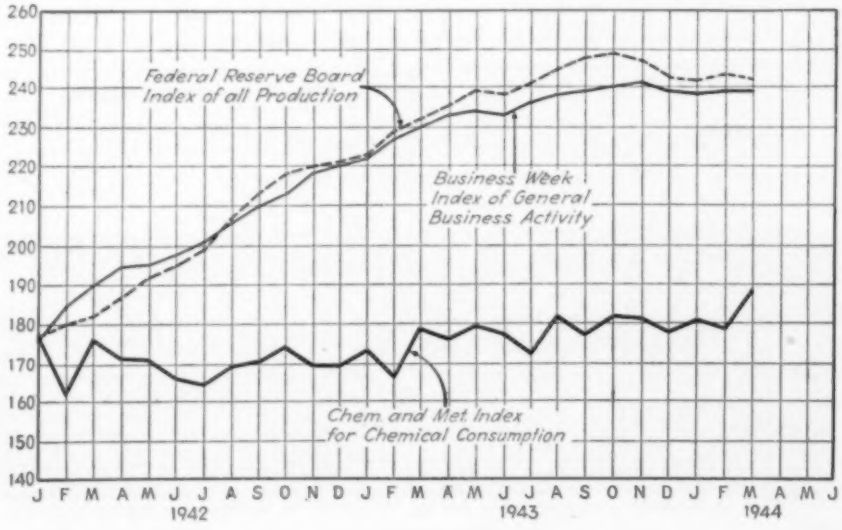
In reviewing first-quarter developments, the Department of Commerce reported that there has been less change in the internal pattern of industrial activity than had been anticipated in some quarters earlier this year. And further stated that no significant resumption of civilian goods production has occurred and there has been little if any over-all reduction in the military program. The report made clear that aside from the manpower situation, the key to large-scale renewal of civilian goods production lies in the availability of supplies of metals and forest products.

Because military requirements reach into nearly every field for products which ordinarily are turned out for civilian use, it is difficult to define the influences which have been most important in moving up the index for industrial consumption of chemicals. The *Chem. & Met.* index for March jumped to 189.49 as compared with 181.14 for February. Last year the indexes were 178.96 and 176.16 respectively. It is probable that the rise in the index this year has resulted from enlarged demands for war purposes and from an attempt on the part of producers to take care of a higher percentage of civilian needs.

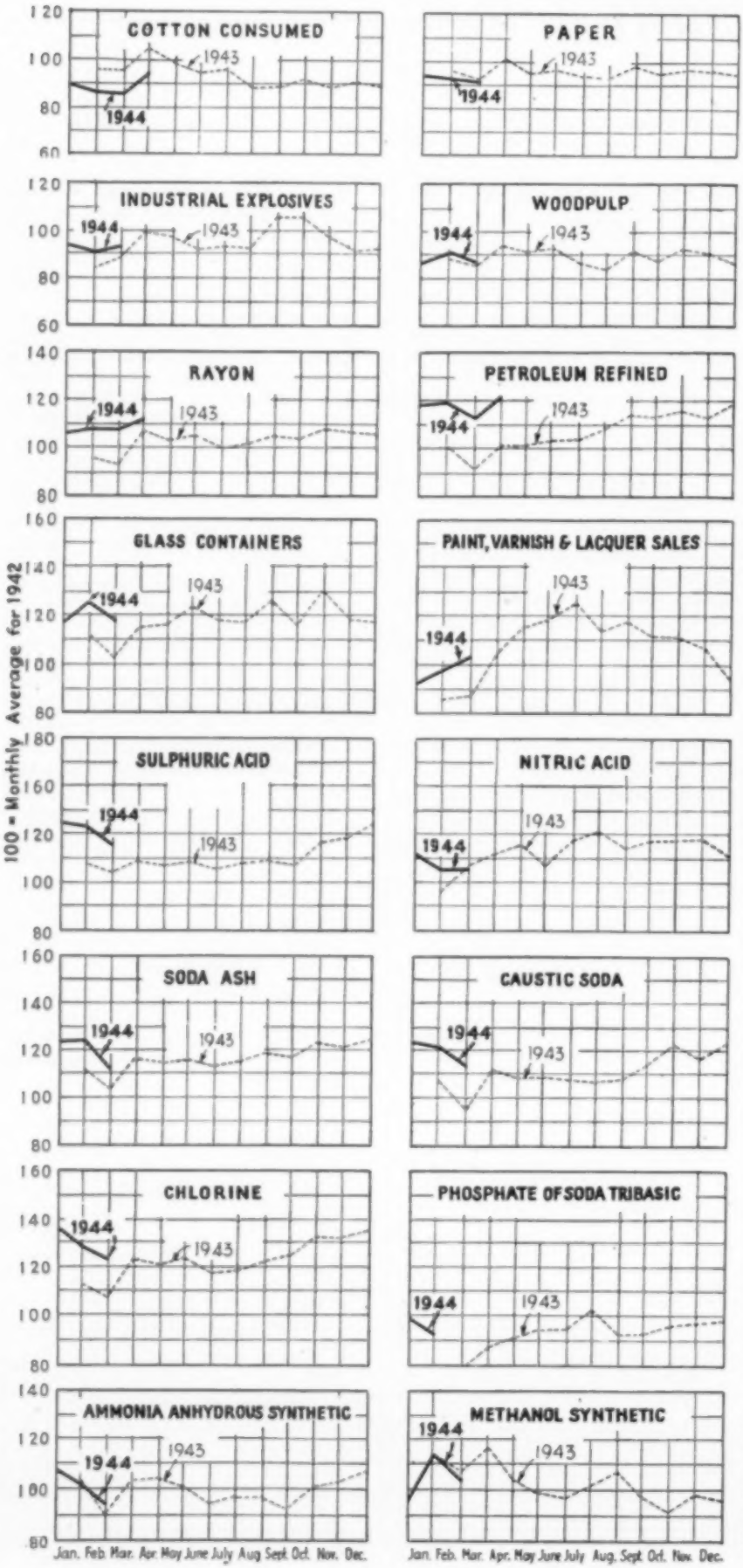
Chem. & Met. Index for Industrial Consumption of Chemicals

1935 = 100

	Feb. revised	March
Fertilizer	44.30	43.52
Pulp and paper	18.70	19.80
Petroleum refining	16.42	17.74
Glass	19.50	20.30
Paint and varnish	14.82	17.42
Iron and steel	12.83	13.80
Rayon	16.38	17.11
Textiles	10.47	11.80
Coal products	9.90	10.20
Leather	4.20	4.20
Industrial explosives	5.32	5.20
Rubber	3.00	3.00
Plastics	5.30	5.40
	181.14	189.49



PRODUCTION AND CONSUMPTION TRENDS



GENERALLY speaking, with the exception of some modifications in the military program, conditions have been favorable for both production and consumption of chemicals. From the viewpoint of consumption, attention is directed to the steadily growing output of synthetic rubber and the completion of new plants for turning out high-octane gasoline. The rubber industry is reaching full-scale operation and more 100-octane plants are coming into operation. In addition rayon mills continue to surpass previous record highs, glass containers are on the way to the highest totals in the history of the industry, and fertilizer sales are now expected to reach a total of 12,000,000 tons in the present season. Demand for paints is reported to be larger than current outputs can take care of, and plastics production is limited only by the availability of raw materials.

Activity in the principal consuming industry, naturally is reflected in the field of production and from the statistics which are made public monthly it is evident that full chemical plant capacity is being utilized in the majority of cases with some government-owned plants going counter to the general rule. While the Federal Reserve Board index for chemicals averages slightly lower for the first quarter of this year compared with the like period of 1943, the same index referring to production of industrial chemicals, indicates an increase of about 10 percent for the present year. Beginning with the current issue the graphic presentation on this page has been changed to plot the monthly progress of some of the most important consuming industries and to include some of the higher tonnage chemicals based on actual figures of output which are now being made available.

There is no shortage of raw materials for textile manufacture. Large stocks of wool are held by government agencies but recent mill operations have been more concerned with imported wool and in February, it was reported that 87 percent of the apparel wool consumed was of foreign origin. Rayon shipments in March fell but little below 61,000,000 lb. and the supply of cotton is fully equal to any demands which may be made.

In the field of coating materials, productive capacity is ample but raw materials are still scarce and this places a limit on production of the finished products. In the case of Vinyl plastics, it was recently announced that production can not be increased to a point where any but military requirements can be filled. Plasticizers are likewise in small supply and in the case of pigments the chrome products are scarce now with the chances favoring a still greater stringency in the future.

The prospects for a larger outlet for chemicals in the munitions program are well defined in the March report which stated that the program is divided with some branches tending downward and others scheduled for progressive rises. It specifies that munitions are in the former group due to adequate stockpiles or other reasons.

"FAIRBANKS-MORSE SCALES—ARBITERS OF BUSINESS"

The Decision Is Final!

Since 1830—Fairbanks-Morse Scales have been rendering split-second decisions recognized as *fair* and *absolute* by buyers and sellers alike.

They are accurate, reliable, honest weighing decisions that have exerted a profound influence on the progress of industries and the welfare of nations.

The accuracy and long life built into Fairbanks-Morse Scales can give you added protection—distinct *plus values* wherever fast—accurate—efficient weighing is essential.

They are tangible *values* developed and pioneered by a company that places no ceiling on whatever it takes to make the finest scales possible to produce.

Fairbanks, Morse & Co., 204 Fairbanks-Morse Building, Chicago 5, Illinois.

BUY WAR BONDS

FAIRBANKS-MORSE

DIESEL ENGINES
PUMPS
MOTORS
GENERATORS
WATER SYSTEMS
SCALES
STOKERS
FARM EQUIPMENT
RAILROAD EQUIPMENT

Scales

United States Production, Consumption and Stocks of Chemicals: February 1944

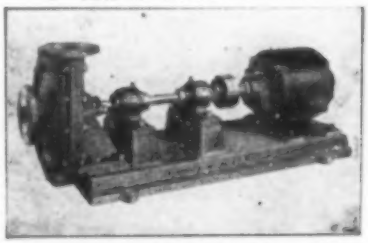
(Data from WPB Chemicals Bureau and U. S. Department of Commerce Bureau of the Census)

Chemical and Basis	Units*	February 1944 (Preliminary) Production	Made and Consumed	Stocks	January 1944 Production	Made and Consumed	Stocks
Acetylene: For use in chemical synthesis	M cu.ft.	[1]	[1]	[1]	324,855	81,190	[1]
For commercial purposes	M cu.ft.	[1]			146,814		
Synthetic anhydrous ammonia (100% NH_3)	Tons	42,963	38,514	4,559	46,487	39,994	5,3
Bleaching powder (35%–37% avail. Cl$_2$)	M lb.	5,805	2,163	1,782	5,595	1,923	1,6
Calcium acetate (80% Ca ($C_2H_3O_2$)$_2$)	M lb.	1,055	[3]	244	1,190	[3]	[3]
Calcium arsenate (100% $Ca_3(AsO_4)_2$)	M lb.	3,957	86	8,812	[2] 2,541	[2] 434	[2] 8,0
Calcium carbide (100% CaC_2)	Tons	[1]	[4]	[4]	59,252	[4]	[2] 14,3
Calcium hypochlorite (true) (70% available Cl$_2$)	M lb.	1,178	[3]	[3] 939	1,098	[3]	[3]
Calcium phosphate — monobasic (100% $CaH_4(PO_4)_2$)	M lb.	5,370	[3]	45,340	5,532	[3]	4,0
Carbon dioxide: Liquid and gas (100% CO_2)	M lb.	[1]	[1]	[1]	25,148	2,124	[2] 5,7
Solid (dry ice) (100% CO_2)	M lb.	[1]	[1]	[1]	37,380	661	6,6
Chlorine	Tons	101,373	57,301	5,405	106,333	61,146	8,7
Chrome green (C.P.)	M lb.	499	42	1,010	[2] 563	73	[2]
Hydrochloric acid (100% HCl)	Tons	28,501	17,092	2,942	29,048	16,499	2,7
Hydrogen	Millions of cu.ft.	[1]	[1]	[4]	1,914	1,581	[4]
Lead arsenate (acid and basic)	M lb.	[1]	[1]	[1]	7,212	163	6,3
Lead oxide — red (100% Pb_3O_4)	M lb.	8,453	574	5,042	9,218	651	5,3
Methanol: Natural (100% CH_3OH)	Gal.	347,439	[4]	233,363	374,611		189,8
Synthetic (100% CH_3OH)	M gal.	5,419	[3]	2,208	6,007		5,3
Molybdate orange (C.P.)	Lb.	124,379	1,005	119,950	114,594	2,057	142,8
Nitric acid (100% HNO_3)	Tons	38,153	33,726	8,298	37,621	[2] 35,774	8,3
Oxygen	M cu.ft.	[1]	[1]	[1]	1,560,716	34,310	[1]
Phosphoric acid (50% H_3PO_4)	Tons	61,887	57,130	12,491	[2] 65,003	[2] 58,267	[2] 11,8
Potassium bichromate and chromate (100%)	M lb.	714	[3]	499	763	[3]	[3]
Potassium chloride (100% KCl)	Tons	99,749	[3]	17,185	103,125	[3]	25,2
Potassium hydroxide (caustic potash) (100% KOH)	Tons	3,362	773	2,014	3,558	902	2,0
Soda ash — Ammonia soda process:							
Total wet and dry [5] (98%–100% Na_2CO_3)	Tons	363,875	.....	.....	393,474	.....	.....
Finished light (98%–100% Na_2CO_3) [6]	Tons	201,714	45,749	21,611	[2] 220,905	51,093	22,0
Finished dense (98%–100% Na_2CO_3)	Tons	113,011	4,796	8,028	121,236	3,238	9,0
Natural [7]	Tons	[3]	[3]	[3]	13,479	.....	[2] 1,1
Sodium bicarbonate (refined) (100% $NaHCO_3$)	Tons	13,774	[3]	4,655	13,498	[3]	4,0
Sodium bichromate and chromate (100%)	Tons	7,088	[3]	1,064	7,029	[3]	[3]
Sodium hydroxide, liquid: Electrolytic process (100% NaOH)	Tons	94,286	23,909	36,732	100,619	26,597	37,2
Lime-soda process (100% NaOH)	Tons	53,709		14,544	57,593	[3]	15,2
Sodium phosphate: Monobasic (100% NaH_2PO_4)	M lb.	[1]	[1]	[1]	2,375	[1]	[1]
Dibasic (100% Na_2HPO_4)	Tons	[1]	[1]	[1]	4,008	[1]	[1]
Tribasic (100% Na_3PO_4)	Tons	[1]	[1]	[1]	5,995	136	1,1
Sodium silicate (water glass): Liquid (40° Baumé)	Tons	133,163	[4]	229,225	106,681	[4]	242,5
Solid (all forms combined)	Tons	8,351	2,411	8,868	8,210	2,527	9,4
Sodium sulphate: Glauber salt and crude salt cake [7]	Tons	[1]	[1]	[1]	64,174	7,285	70,4
Anhydrous (refined) (100% Na_2SO_4)	Tons	[1]	[1]	[1]	11,513	[1]	9,2
Sulphur dioxide (100% SO_2)	M lb.	[1]	[1]	[1]	5,685	3,286	3,0
Sulphuric acid: [8] Chamber process (100% H_2SO_4)	Tons	284,027	.....	292,753	287,266	.....	273,8
Contact process [9] (100% H_2SO_4)	Tons	439,873	.....		[2] 501,055	.....	
Net contact process [9] (100% H_2SO_4)	Tons	414,732	.....	.....	[2] 455,042	.....	.....
White Lead	Tons	6,826	2,629	9,029	6,914	1,976	9,4
Zinc yellow (C.P.)	M lb.	1,707	204	508	2,230	237	[3]

* All tons are 2,000 lb. [1] Not yet available. [2] Revised. [3] Data cannot be published. [4] Not available. [5] Total wet and dry production, including quantities converted to finished dense. [6] Data collected in cooperation with Bureau of Mines. [7] Includes oleum grades. [8] Excl spent acid.

LAWRENCE PUMPS

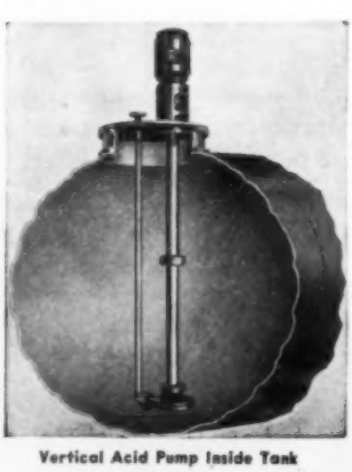
FOR PUMPING HOT ACIDS



Acid Pump in Lead

LAWRENCE CENTRIFUGAL PUMPS are available—in both horizontal and vertical types—for handling hot acids (including sulphuric acid), acid solutions, acid slurries, fruit juices, etc. Not only are the pumps themselves acid-resistant; there is no alteration in the fluid pumped, due to chemical reaction.

Materials used in the exposed pump parts—shaft, impeller and casing—are determined by the chemical characteristics of the fluid. We have built pumps of such resistant materials as Monel metal, stainless steel, Hastelloy, Ni-Resist, Ni-Hard, Durimet, Duraloy, Illium, etc. And each LAWRENCE CENTRIFUGAL is individually designed and built for long life and high economy under the customer's specific operating conditions. Let us work with you on your difficult pumping problems. Avail yourself of our 80-odd years of experience. Write for Bulletin 203-3.



Vertical Acid Pump Inside Tank

LAWRENCE MACHINE & PUMP CORP.
369 Market Street LAWRENCE, MASS.

LAWRENCE CENTRIFUGALS FOR EVERY PUMPING DUTY

BULL'S EYE ACCURA

for pH MEASUREME

NO BATTERY NUISANCE

Operated from 110 volt A. C. let. CAMBRID self-contained portable pH me are always "re to-go". These in ments may be turned on continuously that they are available without the ne sity of a warm-up period to obtain bility. The electron-ray null indica immune to danger from mismanipula replaces the conventional, delicate poi galvanometer.

LABORATORY MODEL Accuracy .02 pH. Sensitivity .005 pH. Readings Reproducible to .01 pH. Range 0 to 14 pH and 0 to 1200 m.

INDUSTRIAL MODEL Accuracy .05 pH. Sensitivity .01 pH. Readings Reproducible to .02 pH. Range 0 to 14 pH and 0 to 1000 m.

CAMBRIDG INSTRUMENT CO., INC.
3732 Grand Central Terminal, New York
For complete information send for Bulletin

At your service FAST!

0 men, covering every major industrial area, ch man backed by 73 years' experience — 's the Willson Safety Service set-up! Your illson man is as near as your phone.

anta—Fulton Supply Co.
timore—Carey Mach. & Sup. Co.
rmingham—Owen-Richards Co.
falo—American Allsafe Co.
mbridge, Mass.—Cutter, Wood & Sanderson Co.
arleston, S. C.—Cameron & Barkley Co.
arleston, W. Va.—Safety First Supply Co.
attanooga—C. D. Genter Co.
icago—Protective Equipment, Inc.
cinnati—The E. A. Kinsey Co.
veland—Safety Clothing & Equipment Co.
umbus, O.—The E. A. Kinsey Co.
ver, Colo.—The E. A. Kinsey Co.
roit—E. D. Bullard Co.
Willson Products, Inc.
nd Rapids—J. Raniville Co.
ensboro, N. C.—Smith-Courtney Co.
enville, S. C.—Carolina Sup. Co.
ory, N. C.—Smith-Courtney Co.
olulu and Hilo—Theo. H. Davies & Co., Ltd.
ston—E. D. Bullard Co.
anapolis—The E. A. Kinsey Co.
ksonville—Cameron & Barkley Co.
sas City—L. R. Stone Supply Co.
Angeles—E. D. Bullard Co.
Louisville—Neill-LaVielle Co., Inc.
Memphis—J. E. Dilworth Co.
Milwaukee—Protective Equip., Inc.
Muskegon—Factory Supply Co.
New Orleans—Woodward, Wight & Co., Ltd.
New York—W. S. Wilson Corp.
Oklahoma City—Hart Industrial Supply Co.
Omaha—Interstate Mach. & Sup. Co.
Philadelphia—Industrial Prod. Co.
Pittsburgh—Safety First Supply Co.
Providence—James E. Tierney
Richmond, Va.—Smith-Courtney Co.
St. Louis—Safety Incorporated
St. Paul—Farwell, Ozmun, Kirk & Co.
Salt Lake City—E. D. Bullard Co.
San Francisco—E. D. Bullard Co.
Scranton—L. B. Potter Co.
Seattle—E. D. Bullard Co.
Springfield, Mass.—Charles C. Lewis Co.
Syracuse—Syracuse Supply Co.
Tampa—Cameron & Barkley Co.
Troy, N. Y.—The Troy Belt & Sup. Co.
Tulsa, Okla.—Hart Ind. Supply Co.
Toronto—Safety Sup. Co.
Montreal—Safety Sup. Co.
Vancouver—Safety Supply Co.

GOGGLES • GAS MASKS • HELMETS • RESPIRATORS

WILLSON

PRODUCTS INCORPORATED

READING, PA., U. S. A. *Established 1870*

C. M. H. Stainless Steel BELLOWS Are Standard Production Items

C. M. H. Stainless Steel BELLOWS are standard production products; hence, shipping delays are minimized. All the advantages of *Stainless Steel* have been utilized in the art and craftsmanship of C. M. H. BELLOWS. They are the solution to both difficult and urgent requirements.

C. M. H. Stainless Steel BELLOWS are corrosion resistant and operate efficiently at either high or low temperatures. They have the qualities required for handling high pressures—which may be further increased by multiple ply construction, where needed. Ferrous fittings attached by circular seam welding, give uni-metal assembly and assure non-corrosion of the assembled parts.

C. M. H. engineers and production will help you solve your immediate bellows problems—where they are to be required for valve stem housing on vacuum equipment, thermostats, pressure controls, valves, recording instruments, hydraulic mechanisms, rotating shaft seals, or other purposes. Write for complete information today.

Ask for Chicago Metal Hose Engineering Take-off Form SSB2 on which to submit your bellows requirements. It will save you time — assure more accurate, expeditious handling.

Flexible Metal Hose for Every Industrial Use

CMH

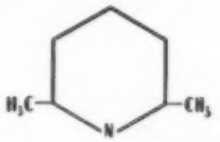
CHICAGO METAL HOSE CORPORATION

MAYWOOD, ILLINOIS

Plants: Maywood and Elgin, Ill.

Reilly
COAL TAR PRODUCTS

2, 6-LUTIDINE



PURITY: Ninety-five per cent minimum.

DISTILLATION RANGE: Ninety-five per cent shall distill within a range of 2.0°C., including the temperature of 143.8°C.

SOLUBILITY: Very soluble in water, soluble in most common organic solvents, including alcohols, ethers, esters, ketones, aliphatic and aromatic hydrocarbons.

USES: Pharmaceuticals, resins, dyestuffs, rubber accelerators, insecticides, and as a solvent substitute for pyridine.

APPROXIMATE WEIGHT PER GALLON: 7.72-lbs.

SHIPPING CONTAINERS: 400-lb. drums; 35-lb. cans.

A Dependable Source of Supply
For All Coal Tar Products

● With unusual production and delivery facilities, plants in 17 strategic locations, and offices in major cities, Reilly offers a complete line of coal tar bases, acids, oils, chemicals and intermediates. Booklet describing all of these products will be mailed on request.

REILLY TAR & CHEMICAL CORPORATION

Executive Offices: Merchants Bank Building, Indianapolis, Indiana

2513 S. DAMEN AVE., CHICAGO, ILL. 500 FIFTH AVE., NEW YORK, N.Y.

ST. LOUIS PARK, MINNEAPOLIS, MINN.

Reilly COAL TAR PRODUCTS
★ 17 PLANTS *To Serve the Nation*

CHEM & MET.
Weighted Index of Prices for CHEMICALS

Base = 100 for 1937

This month	109
Last month	109
May, 1943	108
May, 1942	109

CURRENT PRICES

The accompanying prices refer to round lo
Where it is trade custom to sell fob wor
quotations are so designated. Prices are c
rected to May 10

INDUSTRIAL CHEMICALS

Acetone, tanks, lb	$0.07 –
Acid, acetic, 28%, bbl., 100 lb	3.38 – $3.6
Boric, bbl., ton	109.00 –113.0
Citric, kegs, lb	.20 –
Formic, cbys, lb	.10½–
Hydrofluoric 30% drums, lb	.08 –
Lactic, 44%, tech., light, bbl., lb	.073–
Muriatic, 18°, tanks, 100 lb	1.05 –
Nitric, 36°, carboys, lb	.05 –
Oleum, tanks, wks., ton	18.50 – 20.0
Oxalic, crystals, bbl., lb	.11½–
Phosphoric, tech., tanks, lb	.04 –
Sulphuric, 60°, tanks, ton	13.00 –
Tartaric, powd., bbl., lb	.70½–
Alcohol, amyl	–
From Pentane, tanks, lb	.131–
Alcohol, butyl, tanks, lb	.10½–
Alcohol, ethyl, denatured, 190 proof	–
No. 1 special, tanks, gal. wks	.50 –
Alum, ammonia, lump, bbl., lb	.04½–
Aluminum sulphate, com., bags, 100 lb	1.15 – 1.4
Aqua ammonia, 26°, drums, lb	.02½–
tanks, ton	65.00 –
Ammonia, anhydrous, cyl., lb	.16 –
tanks, lb	.04½–
Ammonium carbonate, powd. tech., casks, lb	.09½–
Sulphate, wks, ton	28.20–
Amylacetate tech., from pentane, tanks, lb	.145–
Arsenic, white, powd., bbl., lb	.04 –
Barium, carbonate, bbl., ton	60.00 – 65.0
Chloride, bbl., ton	79.00 – 81.0
Nitrate, casks, lb	.11 –
Blanc fix, dry, bags, ton	60.00 – 70.0
Bleaching powder, f.o.b., wks., drums, 100 lb	2.50 – 3.0
Borax, gran., bags, ton	45.00 –
Calcium acetate, bags	3.00 –
Arsenate, dr. lb	.07 –
Carbide drums, ton	50.00 –
Chloride, flake, bags, del., ton	18.50 – 23.0
Carbon bisulphide, drums, lb	.05 –
Tetrachloride drums, gal	.73 –
Chlorine, liquid, tanks, wks., 100 lb	1.75 – 2.0
Copperas, bgs., f.o.b., wks., ton	17.00 – 18.0
Copper carbonate, bbl., lb	.19½–
Sulphate, bbl., 100 lb	5.00 – 5.3
Cream of tartar, bbl., lb	.57 –
Diethylene glycol, dr. lb	.14 –
Epsom salt, dom., tech., bbl., 100 lb	1.90 – 2.0
Ethyl acetate, tanks, lb	.11½–
Formaldehyde, 40%, tanks, lb	0.36 –
Furfural, tanks, lb	.09 –
Glaubers, salt, bags, 100 lb	1.05– 1.2
Glycerine, e.p., drums, extra, lb	.18½–
Lead:	
White, basic carbonate, dry casks, lb	.08½–
Red, dry, sck, lb	.09½–
Lead acetate, white crys, bbl., lb	.12½–
Lead arsenate, powd., bag, lb	.11½–
Lithopone, bags, lb	.04½–
Magnesium carb, tech., bags, lb	.06½–
Methanol, 95%, tanks, gal	.58 –
Synthetic, tanks, gal	.28 –
Phosphorous, yellow, cases, lb	.25 –
Potassium bichromate, casks, lb	.09½–
Chlorate, powd., lb	.09½–
Hydroxide (caustic potash) dr., lb	.07 –
Muriate, 60% bags, unit	.53½–
Nitrate, bbl., lb	.05½–
Permanganate, drums, lb	.19½–
Prussiate, yellow, casks, lb	.17 –
Sal ammoniac, white, casks, lb	.05½–
Salsoda, bbl., 100 lb	1.00 – 1.1
Salt cake, bulk, ton	15.00 –
Soda ash, light, 58%, bags, contract, 100 lb	1.05 –
Dense, bags, 100 lb	1.15 –
Soda, caustic, 76%, solid, drums, 100 lb	2.30 – 2.4
Acetate, del., bbl., lb	.05 –
Bicarbonate, bbl., 100 lb	1.70 – 1.8
Bichromate, casks, lb	.07½–
Bisulphate, bulk, ton	16.00 – 17.0
Bisulphite, bl., lb	.03 –

CHEM. & MET.
Weighted Index of Prices for OILS & FATS

Base = 100 for 1937

This month	**145.24**
Last month	145.24
May, 1943	146.93
May, 1942	143.93

Chlorate, kegs, lb	.06½ –	.06¾
Cyanide cases, dom., lb	.14½ –	.15
Fluoride, bbl., lb	.07 –	.08
Hyposulphite, bbl., 100 lb	2.40 –	2.50
Metasilicate, bbl., 100 lb	2.50 –	2.65
Nitrate, bulk, 100 lb	1.35 –	
Nitrite, casks, lb	.06½ –	.07
Phosphate, tribasic, bags, lb	2.70 –	
Prussiate, yel. bags, lb	.9½ –	.10
Silicate (40° dr.), wks., 100 lb	.80 –	.85
Sulphide, bbl., lb	.02½ –	
Sulphite, crys., bbl., lb	.02¼ –	.02½
Sulphur, crude at mine, long ton	16.00 –	
Dioxide, cyl., lb	.07 –	.08
Tin crystals, bbl., lb	.39½ –	
Zinc, chloride, gran, bbl., lb	.05½ –	.06
Oxide, lead free, bag, lb	.07½ –	
5% leaded, bags, lb	.07½ –	
Sulphate, bbl., cwt	3.85 –	4.00

OILS AND FATS

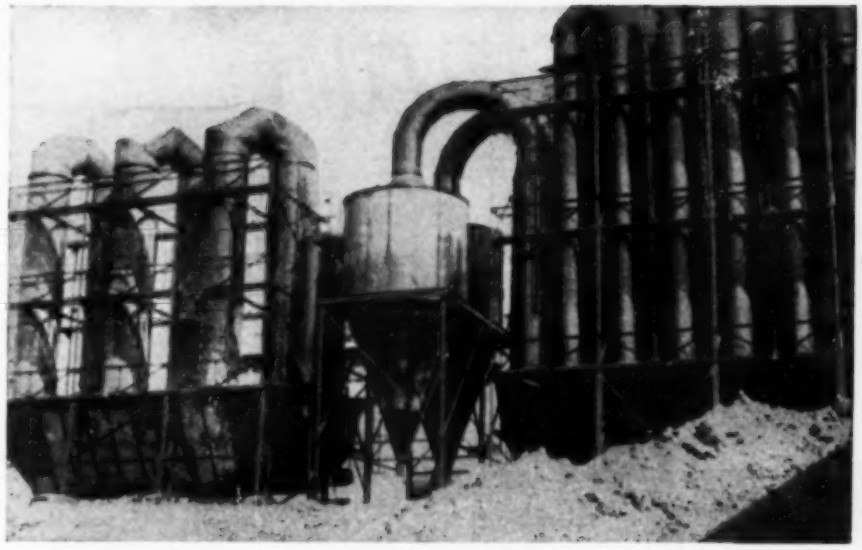
Castor oil, No. 3 bbl., lb	$0.13½ –	$0.14¼
Chinawood oil, bbl., lb	.38 –	
Coconut oil, ceylon, tank, N. Y., lb	nom	
Corn oil crude, tanks (f.o.b. mill), lb	.12¼ –	
Cottonseed oil, crude (f.o.b. mill), tanks, lb	.12½ –	
Linseed oil, raw car lots, bbl., lb	.15½ –	
Palm casks, lb	.09 –	
Peanut oil, crude, tanks (mill), lb	.13 –	
Rapeseed oil, refined, bbl., lb	nom	
Soya bean, tank, lb	.11½ –	
Menhaden, light pressed, dr., lb	.1305 –	
Crude, tanks (f.o.b. factory) lb	.089 –	
Grease, yellow, loose, lb	.08½ –	
Oleo stearine, lb	.09½ –	
Oleo oil, No. 1	.11¼ –	
Red oil, distilled, dp p. bbl., lb	.11½ –	
Tallow extra, loose, lb	.08½ –	

COAL-TAR PRODUCTS

Alpha-napthol, crude bbl., lb	$0.52 –	$0.55
Alpha-naphthylamine, bbl., lb	.32 –	.34
Aniline oil, drums, extra, lb	.15 –	.16
Aniline, salts, bbl., lb	.22 –	.24
Benzaldehyde, U.S.P., dr., lb	.85 –	.95
Benzidine base, bbl., lb	.70 –	.75
Benzoic acid, U. S. P., kgs., lb	.54 –	.56
Benzyl chloride, tech., dr., lb	.23 –	.25
Benzol, 90%, tanks, works, gal	.15 –	
Beta-naphthol, tech., druma, lb	.23 –	.24
Cresol, U.S.P., dr., lb	.11 –	
Cresylic acid, dr., wks., gal	.81 –	.83
Diphenyl, bbl., lb	.15 –	
Diethylaniline, dr., lb	.40 –	.45
Dinitrophenol	.23 –	.25
Dinitrotoluol bbl., lb	.18 –	.19
Dip oil, 15%, dr., gal	.23 –	.25
Diphenylamine, dr. f.o.b. wks., lb	.60 –	
H-acid, bbl., lb	.45 –	.50
Hydroquinone, bbl., lb	.90 –	
Naphthalene, flake, bbl., lb	.07 –	.07½
Nitrobenzene, dr., lb	.08 –	.09
Paracresol, bbl., lb	.41 –	
Para-nitraniline, bbl., lb	.47 –	.49
Phenol, U.S.P., druma, lb	.10½ –	.11
Picric acid, bbl., lb	.35 –	.40
Pyridine, dr., gal	1.70 –	1.80
Resorcinol, tech., kegs, lb	.75 –	.80
Salicylic acid, tech., bbl., lb	.33 –	.40
Solvent naphtha, w.w., tanks, gal	.27 –	
Tolidine, bbl., lb	.86 –	.88
Toluol, druma, works, gal	.33 –	
Xylol, com., tanks, gal	.26 –	

MISCELLANEOUS

Casein, tech., bbl., lb	$0.21 –	$0.24
Dry colors		
Carbon gas, black (wks.), lb	.0335 –	.30
Prussian blue, bbl., lb	.36 –	.37
Ultramarine blue, bbl., lb	.11 –	.26
Chrome green, bbl., lb	.21½ –	.30
Carmine, red, tins, lb	4.60 –	4.75
Para toner, lb	.75 –	.80
Vermilion, English, bbl., lb	2.75 –	2.80
Chrome yellow, C.P., bbl., lb	.14½ –	.15½
Gum copal Congo, bags, lb	.09 –	.30
Manila, bags, lb	.09 –	.15
Damar, Batavia, cases, lb	.10 –	.22
Kauri, cases, lb	.18 –	.60
Magnesite, calc., ton	64.00 –	
Pumice stone, lump, bbl., lb	.05 –	.07
Rosin, H., 100 lb	5.40 –	
Turpentine, gal	.86½ –	
Shellac, orange, fine, bags, lb	.39 –	
Bleached, bonedry, bags, lb	.39 –	
T. N. bags, lb	.31 –	



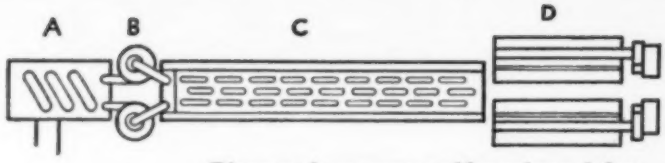


Diagram shows course of fume through first stage cooling (A), centrifugal separators (B), second stage cooling (C) and bag houses (D). Fume is 900° at start and 200° at Norblo Bag Type Collectors.

Fume Collection Costs You Less Because of Norblo Know-How

In the reclaiming of zinc from old slag piles, an outstanding achievement of war technology, Norblo Bag Type Fume Collectors are proving their high efficiency and the adaptability of Norblo engineering.

A typical Norblo installation is diagrammed and explained above. In the illustration note the hoppers below the cooling tubes, serving as expansion chambers causing velocity drop and some gravity separation as the fume travels.

The physics of fume and dust collection is simple enough. But the design and construction of a system that will collect the highest percentage of fume particles at lowest cost, and maintain this efficiency under continuous 24-hour operation for months or years, calls for engineering skill and specialized practical experience which are neither simple nor common.

If you have a fume or dust collecting situation consult Norblo engineers, without obligation.

Norblo

DUST COLLECTION SYSTEMS

THE NORTHERN BLOWER COMPANY
6411 BARBERTON AVENUE CLEVELAND 2, OHIO

NEW CONSTRUCTION

	Current Projects		Cumulative 1944	
	Proposed Work	Contracts	Proposed Work	Contracts
New England	$500,000	$102,000	$540,000	$1,356,000
Middle Atlantic	40,000	40,000	5,765,000	7,615,000
South	.....	2,080,000	9,985,000	13,754,000
Middle West	110,000	75,000	405,000	8,607,000
West of Mississippi	1,080,000	110,000	16,345,000	12,900,000
Far West	3,500,000	740,000	4,120,000	7,220,000
Canada	4,499,000	365,000	7,239,000	5,337,000
Total	$9,729,000	$3,512,000	$44,399,000	$56,789,000

PROPOSED WORK

Conn., Naugatuck—Naugatuck Chemical Co., Div. of United States Rubber Co., Elm St., is having plans prepared by Fletcher-Thompson, Inc., 211 State St., Bridgeport, for expansions to its plant including laboratory, administration building, etc. Project will be financed by Defense Plant Corp., Wash., D. C. Estimated cost will exceed $500,000.

Ind., Indianapolis—U. S. Rubber Co., 549 East Georgia St., has had plans prepared by G. L. Hawkins, Engr., 10 Rockefeller Plaza, New York, N. Y., for the construction of a 1 story, 50x111 ft. factory addition. Estimated cost $70,000.

Mo., Mexico—Missouri Farm Assn., Mexico, is having plans prepared by Horner & Wyatt, Engrs., for the construction of a soybean mill and processing plant to replace the one recently destroyed by fire.

N. J., Berkeley Heights—Manufacturing Chemical Co., Snyder Ave., plans to construct a 1 and 2 story factory.

Tex., Edinburg—Chicago Corp. Oil & Gas Div. & Associates, Heep Bldg., Corpus Christi, plans to construct and equip a large recycling plant in the Los Indos pasture area. Estimated cost $1,000,000.

Tex., Houston—Texas Creosoting Co., 7201 Hardy St., plans to reconstruct its main plant building. Estimated cost $40,000.

Wash., Longview—Owens-Illinois Glass Corp., 135 Stockton St., San Francisco, Calif., plans to construct a plant here consisting of 14 buildings. The Austin Co., Ray Bldg., Oakland, Calif., Engr. Estimated cost $3,500,000. Postwar project.

Wis., Ladysmith—Peavey Paper Mills, Ladysmith, plans to construct a pulpwood mill to replace the one recently destroyed by fire. Estimated cost will exceed $40,000.

B. C., Vancouver—International Plastics Corp., Ltd., 410 Seymour St., plans to construct an 18x40x75 ft. plant. Estimated cost $49,000.

Ont., Cornwall—Howard Smith Paper Mills, Ltd., 407 McGill St., Montreal, Que., plans the construction of a plant. Estimated cost $50,000.

Ont., Highland Creek—Bikol Manufacturing Co., Ltd., Highland Creek, plans the construction of a plant for the manufacture of disinfectants, germicides, etc. Estimated cost $40,000.

Ont., Paris—The Standard Lime Co., Ltd., Paris, plans to construct two factory buildings. Estimated cost $50,000.

Ont., Welland—Joseph Stokes Rubber Co., Ltd., Bernard St., plans to construct a 1 story, 50x150 ft. factory. Margison & Babcock, 127 Wellington St., W., Toronto, Engrs. Estimated cost $40,000.

Que., LaTuque—Brown Corporation, Ltd., LaTuque, plans to construct a sulphate pulp mill. Estimated cost $3,000,000.

Que., McMasterville—Canadian Industries, Ltd., P. O. Box 10, Montreal, plan to construct and equip a plant here. Estimated cost $40,000.

Que., Temiskaming—Canadian International Paper Co., Ltd., Sun Life Bldg., Montreal, plans the construction of a pulp mill. Estimated cost $1,230,000.

CONTRACTS AWARDED

Calif., Watson—Richfield Oil Co., Sepulveda Blvd., has awarded the contract for the construction of a refinery to The Lummus Co., 634 South Spring St., Los Angeles, at $514,500.

Mass., Canton—Plymouth Rubber Co., Inc., has awarded the contract for the construction of a 1 story plant to Horn Bros., Inc., 23 Miner St., Boston. Estimated cost $60,000.

Mass., Springfield—Monsanto Chemical Co., 812 Monsanto Ave., has awarded the contract for the construction of a 2 story, 60x65 ft. laboratory to Adams & Ruxton Construction Co., 1387 Main St., Springfield. Estimated cost $42,000.

Mo., St. Louis—Purex Corp., 4610 Chippewa St., Zone 16, has awarded the contract for repairing 180x288 ft. factory used for the manufacture of laundry supplies (chemical) to George Cousins Construction Co., Skinner and Delmar Blvds. Estimated cost $70,000.

Pa., Pittsburgh—Waverly Oil Works Co., 54th St. and AV R R., has awarded the contract for the construction of a 1 story, 30x70 ft. wax press building to Pittsburgh Industrial Engineering Co., 2929 Butler St., Pittsburgh. Estimated cost $40,000.

O., Willoughby—Ohio Rubber Co., Ben Hur Ave., has awarded the contract for the construction of a 1 story, 90x200 ft. factory to Gordon C. Rutland, 16 Brown Ave. Estimated cost $75,000.

Ore., Portland—Lloyd A. Fry Roofing Co., 3750 N.W. Yeon Ave., has awarded the contract for the construction of a 150x552 ft. roofing plant to Drake, Wyman & Voss, Inc., Lewis Bldg. Estimated cost $125,000.

Ore., Willbridge—Chipman Chemical Co., Inc., Bound Brook, N. J., has awarded the contract for the construction of a chemical plant here to George H. Buckler Co., Lewis Bldg., Portland. Estimated cost $100,000.

S. C., Spartanburg—Raycord, Inc., Spartanburg, has awarded the contract for a 2 story, 81x104 ft. rayon cord plant to Fiske-Carter Construction Co., Spartanburg. Estimated cost $80,000.

Tenn., Columbia—Monsanto Chemical Co., 1700 South Second St., St. Louis, Mo., has awarded the contract for the construction of a chemical plant to C. G. Kershaw Contracting Co., 2212 20th Ave., S., Birmingham, Ala. Estimated cost will exceed $2,000,000.

Tenn., Columbia—Monsanto Chemical Co., 1700 South Second St., St. Louis, Westfield, N. J., has awarded the contract for the construction of a "Bitumastic" enamel manufacturing plant to Wigton-Abbott Corp., M. Esperson Bldg., Houston. Estimated cost $40,000.

Que., Dolbeau—Lake St. John Power & Paper Co., Ltd., 820 Sun Life Bldg., Montreal, will construct a 2 story, 34x40x129 ft. addition to its plant. Work will be done by owner's forces. Estimated cost $234,500.

Que., Joliette—Standard Lime Co., Ltd., 50 Maitland St., Toronto, Ont., will construct 60x100 ft. and 60x75 ft. plant buildings. Work will be done with own forces. Estimated cost $50,000.

Que., Montreal—Dominion Rubber Co., Ltd., 550 Papineau Ave., Montreal, has awarded the contract for an addition to its plant to Anglin-Norcross Quebec, Ltd., 892 Sherbrooke St., Montreal. Estimated cost $80,000.